PRODUCT ENGINEERING

A McGRAW-HILL PUBLICATION

New York, May, 1930

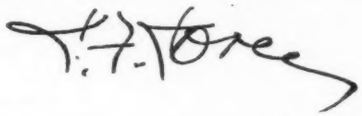
DESIGNING for ECONOMICAL TRANSPORT

ABOUT seven years ago the Delaware and Hudson Company started on a program looking toward the progressive development of a high pressure type of locomotive having an overall efficiency greatly exceeding that of the standard type. The plan of procedure called for a series of three locomotives to operate respectively at 350, 400, and 500 lb. per sq.in. boiler pressure. The last of these locomotives, the James Archbald, D. & H. No. 1402, has just been completed and successfully tested at the Schenectady works of the American Locomotive Company. We feel safe in saying that with the present state of metallurgical art it approaches the ultimate that can be attained in locomotives of its class and type from the point of view of economy both in operation and maintenance.

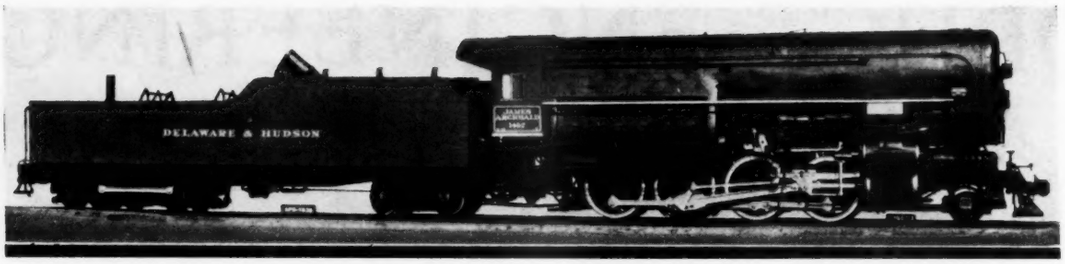
The responsibility of developing these designs was entrusted to John E. Muhlfeld of New York, consulting engineer. In this difficult engineering undertaking he had the full co-operation of G. S. Edmonds, superintendent of motive power of the D. & H. Railroad Corporation, and the assistance of the engineering staff of the American Locomotive Company.

The locomotive James Archbald represents, of necessity, a radical departure from the design of the standard type of locomotive. In order to operate at over double the usual boiler pressure and with a steam temperature of 800 deg. F., it was necessary to resort to hitherto untried constructions and materials. To pioneer into new fields of engineering design, requires the courage of conviction, and knowledge and ability.

Judging from the results of the several years of operation of the first two of these locomotives, and the preliminary tests conducted on the James Archbald, this engineering accomplishment represents the successful completion of another big step in advancing the design of the steam locomotive and in fuel saving. There is no place in the design of power production and application, except the submarine, presenting so great limitations as the locomotive.



President,
The Delaware and Hudson Railroad Corporation



The JAMES ARCHBALD

A LOCOMOTIVE DESIGNED FOR MAXIMUM FUEL SAVINGS ON THE BASIS OF SCIENTIFIC RELATIONSHIPS

An Interview with John E. Muhlfeld

By GEORGE F. NORDENHOLT

Associate Editor

THERMODYNAMIC requirements for the attainment of maximum efficiency in the production of power have long been established. But to meet these requirements in a power plant brings forth a multitude of problems and sets up opposing conditions. If in addition, this power plant is to be in the form of a locomotive, almost numberless construction restrictions are further imposed, and the problem becomes still more difficult. The design of such a machine is complicated not only because of the size and weight limitations, but in addition, the structure is a moving vehicle and must be capable of pulling tremendous loads, and as such, is subjected to great stresses and strains.

With an annual fuel bill of about $400,000,000 charged to railroad locomotive operation, even a relatively small increase in over-all thermal efficiency means a very appreciable saving in dollars. Such an increase in thermal efficiency may be obtained in one of several ways: (1) higher steam pressure and temperature, (2) improved boiler circulation and utilization of heat from combustion, (3) more efficient fuel combustion, (4) more effective use of the steam in the engine, (5) lower exhaust pressure, (6) utilization of waste heat in exhaust steam and stack gases, (7) less radiation losses.

In the design of the D. & H. freight locomotives, Nos. 1400, 1401, and 1402, the principal object was to develop a locomotive using the maximum practical steam pressure and temperature, and decreasing the pressure-heat losses to a minimum. The first of these locomotives, the Horatio Allen, generates steam at 350 lb. per sq.in. pressure, the second, the John B. Jarvis, at 400 lb., and the third, the James Archbald, generates steam at 500 lb. per sq.in. and superheats it to a temperature of from 750 to 800 deg. F. It is believed that with a non-condensing reciprocating engine, about 500 lb. steam pressure and 800 deg. F. temperature is a reasonable limitation, at least with the present state of the metallurgical art, and the method of utilizing the pressure and temperature combination.

The essentials in locomotive boiler design are: the use of self-supporting shapes, such as hollow spherical or cylindrical shapes, in order to obtain the maximum volumetric capacity per unit of tare weight; maximum firebox volume, heating surface, and gas area through fire flues and tubes; relatively short fire flues and tubes in combination with a large combustion chamber; maximum combustion temperature by limiting the size of the grate area; full utilization of radiant heat for evaporation; rapid circulation of water through and around all evaporating surfaces; removal of all steam delivery pipes and throttle valves from inside of boiler and smoke-box; an adequate water capacity and sufficient dry saturated steam space at the top of the boiler; the collection of the dry saturated steam from over a large surface area of the steam-generating water in order to avoid priming and thus preventing the superheater sections from acting as secondary evaporators. The boiler of the D. & H. locomotive, James Archbald, is designed with these points in mind.

IN THE conventional type of locomotive boiler, flat surfaces, particularly those of crown and side sheets, are not a favorable construction for withstanding high internal pressure and high temperature. Such flat surfaces must be well stayed in order to prevent failure from internal pressure. For this and many other reasons it was deemed necessary to depart from the conventional type of locomotive boiler design.

In the boiler design of the James Archbald, a four-drum water tube type of firebox as shown in the elevation and section drawings, takes the place of the ordinary water leg firebox construction. Each of the two upper drums, about 28 in. inside diameter and made of low-carbon nickel steel, is connected to its corresponding

lower drum (about 20 in. inside diameter), by five rows of 2½-in. diameter vertical water tubes. The tubes of the inner row, those exposed to the direct heat of the fire, are made of Allegheny metal in order to better withstand the high temperature. The remainder of the tubes are made of low-carbon steel. There are a total of 286 of these vertical tubes, one-half of them located on each side of the boiler.

Starting near the bottom of the front end of the firebox of the boiler is a fire arch extending upward and rearward toward the rear water header. This arch, which extends the entire length of the firebox, is built up of six water tubes supporting the firebrick. The gases of combustion flow around the side edges of the arch and upward between the vertical water tubes and then under the upper drums, thus reaching the upper compartment of the furnace, where they pass out through the fire tubes and flues to the smokebox.

It can readily be seen that the construction here described and shown in the drawings meets with the requirements of limited grate area for high combustion temperatures, and of maximum firebox volume and evaporating surface and of maximum gas areas through the fire flues and tubes passages. The vertical tubes connecting the upper and lower drums make for a rapid circulation of the water in the boiler, which results in a more rapid absorption of heat from the hot flue gases into the water. With this type of construction, combustion is completed before the furnace gases reach the superheating elements located in the fire flues.

The firebox is sheathed on the sides and top with Ascoloy sheets, for the purpose of replacing the heavier firebrick construction which, experience with the Horatio Allen indicated, was undesirable. Directly beneath the top Ascoloy sheet which covers the spaces between the two upper drums, as shown in the section view, are located six longitudinal water tubes.

The greatest possible use has been made of self-supporting shapes. The design uses cylindrical construction throughout except the headers, which are of uniform section. No staybolts are used in any portion of the boiler except in these headers.

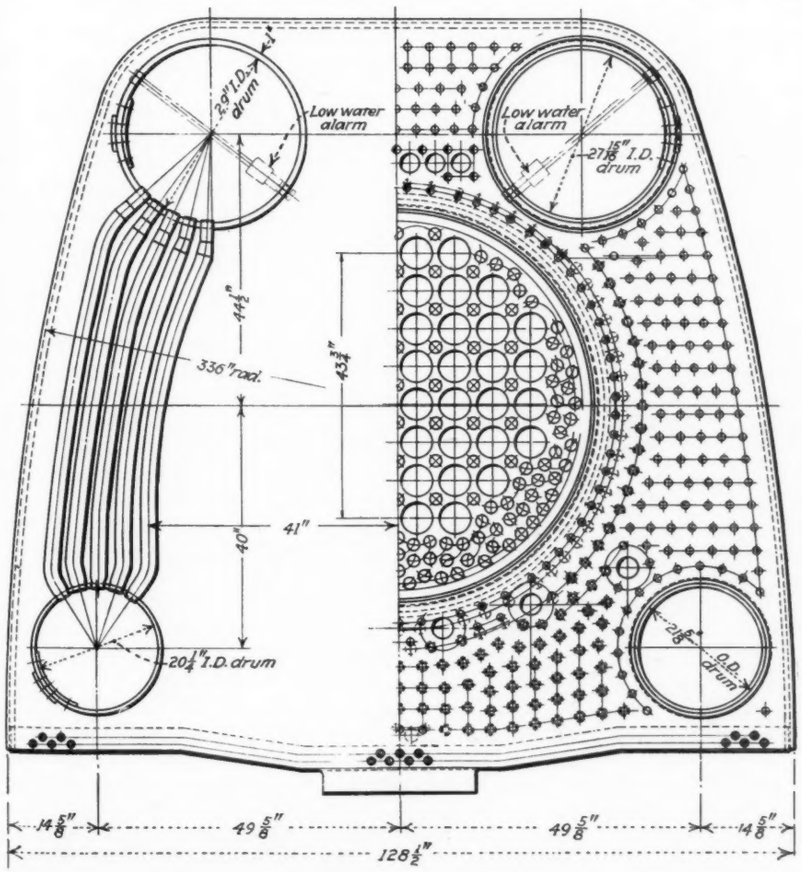
On each side of the boiler, just above the lower drums, are located six handholes to give access for cleaning the soot off of the top of these drums and the water tubes. These are shown in the elevation drawing.

AFTER the products of combustion have passed through the water tube section of the boiler, they enter the fire-flue and tube section or front section. In this front section, which is very similar to the conventional fire-tube boiler, are a total of 52 5½-in. flues, and 155 2-in. fire tubes, extending from the firebox tube sheet to the front tube sheet at the smokebox. These tubes are about 15 ft. long. Double looped superheater tubes are located in the 5½-in. flues and extend within 3 in. of the firebox tube sheet.

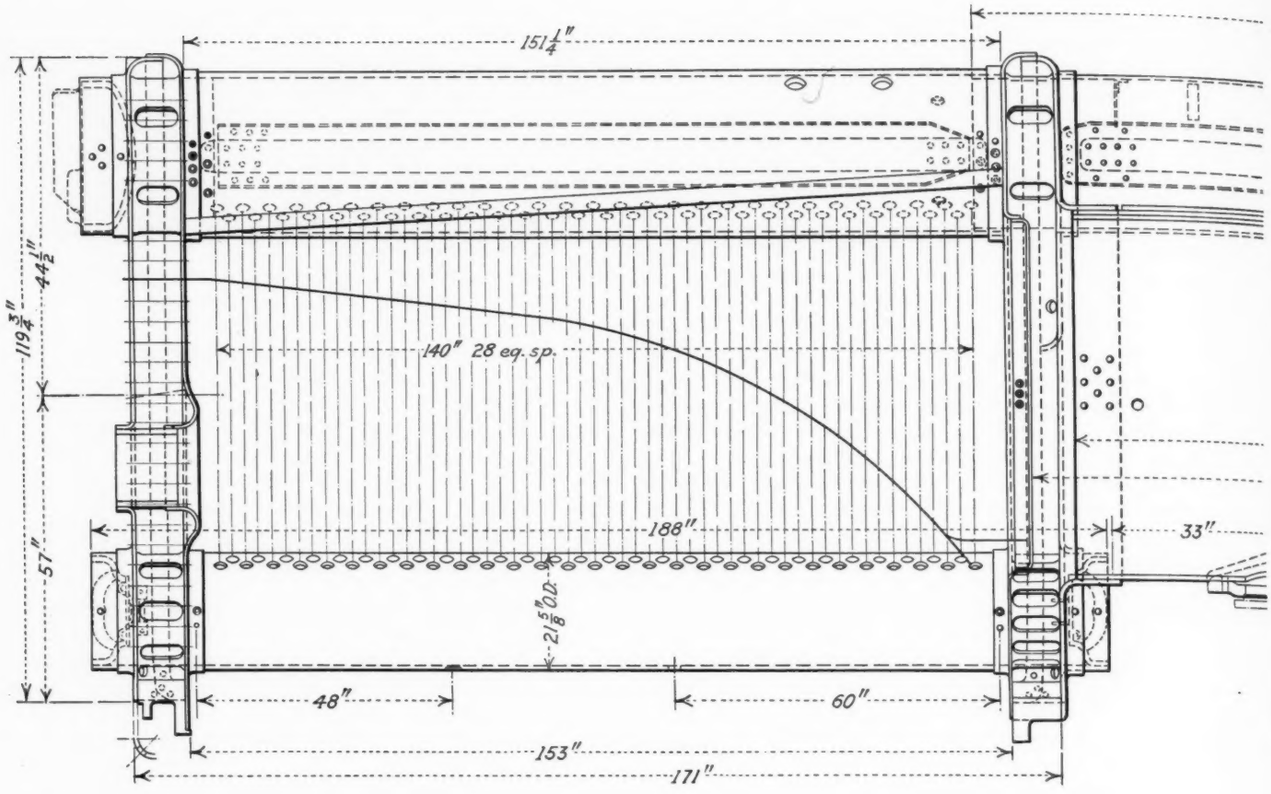
On account of the generous size of the firebox and its evaporative surface and the length and volume of passages from the grate to the entrance of the fire tubes, the process of combustion is completed before the fire flues and tubes are reached.

The dry steam collected from the top of the boiler passes through the superheater elements and is superheated to a temperature of from 750 to 800 deg. F. It then passes through the outside steam delivery pipe and a Wagner single-valve throttle and then to the high-pressure cylinder and to the intercepting valve of the compound cylinder system. A piston valve operated by the conventional Walschaerts valve gear, controls the admission and exhaust of the steam to and from the 20½ in. diameter high-pressure cylinder located on the right side of the locomotive. The engine stroke is 32 in. When the locomotive is running compounded, the exhaust from the high pressure cylinder goes into a receiver from which it enters the low-pressure cylinder which is 35½ in. diameter. The steam from the low-pressure cylinder is released in the conventional manner through an exhaust nozzle into the smokebox and stack, creating a vacuum and draft for the fire.

In the cab of the locomotive is a "simpling" lever which the engineer may operate in order to change the engine from compound to simple. When running simple, the intercepting valve, which is located between the high-pressure cylinder and receiver pipe permits the high-pressure cylinder to exhaust directly to the smokestack while high-pressure steam is fed through the intercepting valve



REAR SECTION at firebox showing drum and tube construction, rear header and tube and flue sheet



to the receiver and thus directly to the low pressure cylinder. The intercepting valve limits the pressure of the steam fed directly to the low-pressure cylinder to a pressure not exceeding 160 lb. per sq.in. When operating as a compound engine the receiver pressure is 135 lb. per sq.in. The purpose of being able to operate as a simple engine is in order to secure an additional 14,000 lb. tractive effort while starting. When the locomotive has attained a speed of 6 to 7 miles per hour, the engine automatically goes into compound operation.

The main frames, crossheads, driving-wheel centers and similar parts are made of Hylastic (low carbon, high manganese) steel having a tensile strength of 105,000 lb. per sq.in. and a yield point of 65,000 lb. per sq.in., with an ultimate elongation of 25 per cent, and a reduction of area of 50 per cent. The crosshead shoes are bronze.

The top crosshead guide is attached to the back cylinder head by means of an Alco expansion shoe. This consists of a lug cast integral with the cylinder head and extending over the top surface of the guide. A close fitting slot in the bottom of the lug mates with the crosshead guide, holding it firmly in alignment yet permitting it to creep in and out, thus relieving it of any stresses that would result from relative longitudinal movements between the cylinder and guide yoke.

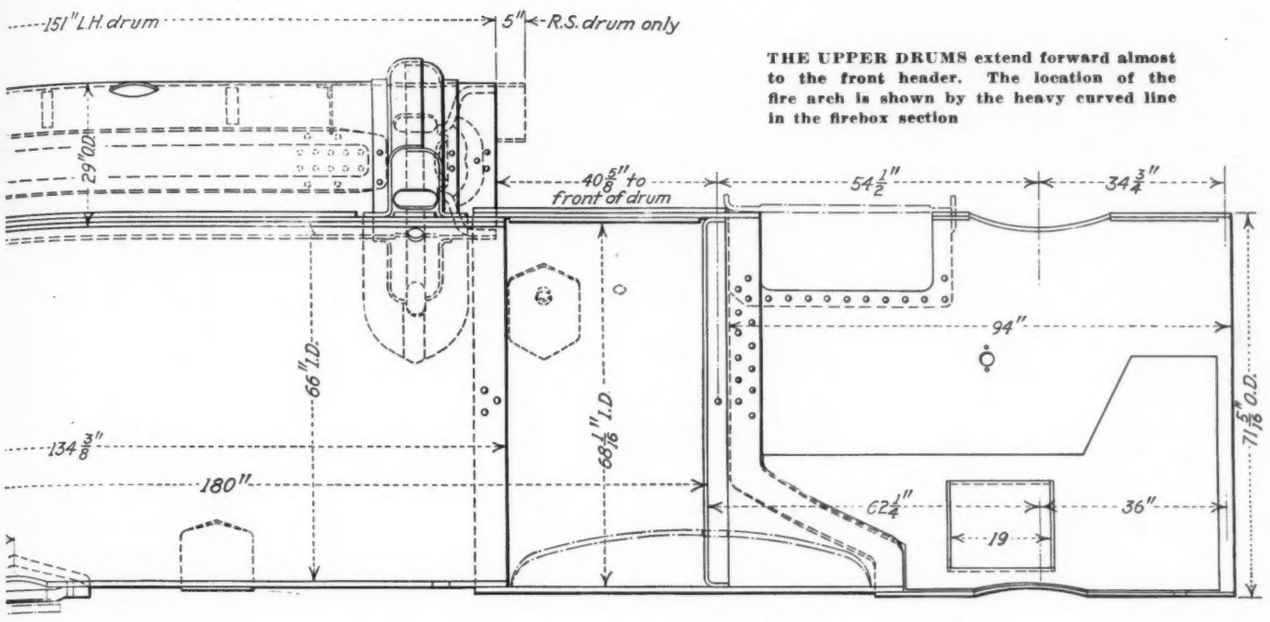
A Becker type wrist pin connects the main rod with the cross-head. The feature of this pin is the ease with which it may be removed. It is merely necessary to knock out a tapered key, reverse it, and drive it down. This results in a wedging action which withdraws the key from the crosshead. The crosshead keys are of chrome-vanadium steel.

The connecting rods and crank pins are of nickel steel. The main crank pin has a 3-in. central longitudinal hole bored through it, and the other crank pins have a similar 2-in. hole. The purpose of these holes is not so much to reduce weight but rather to locate internal material defects and to obtain more uniform heat treatment and a finer grain in the metal.

DRIVING wheels are 63 in. diameter, mounted on nickel-steel axles with 12x14-in. journals for the main driving wheel axle, and 11x14-in. journals for the other three axles. The total working load on the driving wheels is 300,000 lb. which gives an average static bearing pressure of about 240 lb. per sq.in. of projected area. When running, the vertical oscillations increase this load by about 10 per cent. The loaded weight on the leading truck is 56,000 lb., making the total loaded weight of the engine 356,000 lb. The tender, with 14,000 gal. of water and 17½ tons of coal, and including the auxiliary locomotive, weighs 277,500 lb. The adhesive or productive weight on the driving wheels is 84.3 per cent, which is relatively high, particularly as compared with the modern designs of freight locomotives which have one or two pairs of lead truck wheels and one or two pairs of trailer truck wheels under the engine proper, which are not coupled in with the main cylinders and produce no tractive effort or hauling capacity. The driving wheels are 63 in. diameter, 6 in. greater in diameter than those of the two sister locomotives. With the higher boiler pressure, it is possible to do this and still obtain a high tractive effort. It has the advantage of reducing the revolutions per mile and decreasing the reciprocating forces and improving the counterbalancing of the revolving and reciprocating weights.

The tractive effort of this locomotive is 84,300 lb. when operating as a simple engine, 71,000 lb. when compounding. An additional 18,000 lb. tractive effort is furnished by the Bethlehem auxiliary locomotive carried under the rear of the tender.

Because of the use of high pressure and high temperature steam, it is absolutely necessary for efficiency

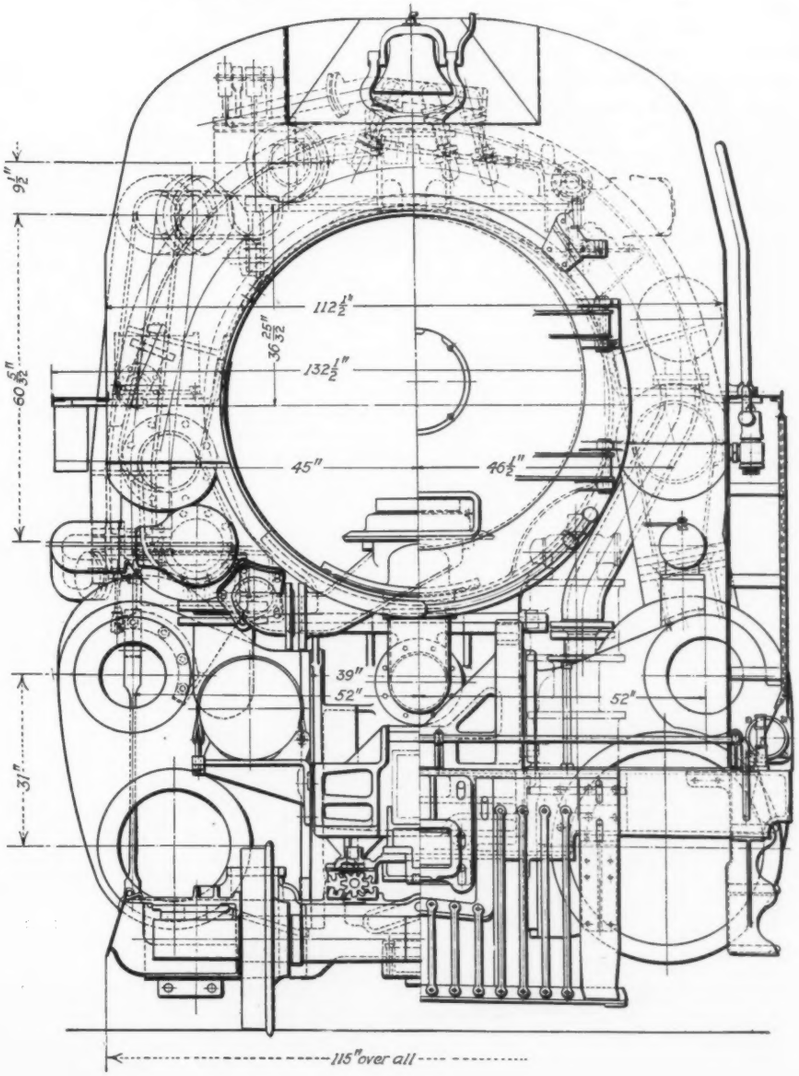


THE UPPER DRUMS extend forward almost to the front header. The location of the fire arch is shown by the heavy curved line in the firebox section

and economy that an adequate range of expansion be available in the cylinders. This was provided for by compounding, that is, using a high-pressure and a low-pressure cylinder. Of course, a large expansion range can also be obtained by limiting the cutoff, but this also limits the otherwise available boiler, engine and adhesive weight capacity of the locomotive. Therefore, with high steam pressures and temperatures, compound cylinders, or an equivalent in multiple expansion should be employed in order to obtain an economical expansion ratio. The location of the cylinders, valve chests and valve gears outside of the main engine frame provides the most practical and accessible arrangement.

IN ORDER to reduce heat radiation losses to a minimum, all of the heated surfaces of the locomotive are well covered with insulating material. All outside surfaces subjected to the temperature of the superheated steam, such as the valve chest, cylinder, cylinder heads and steam pipes, are covered with ½ in. to 1½ in. of Superex block, an asbestos product, on top of which are two courses of sponge felt 1½ in. thick. All other parts of the locomotive surface at which heat radiation losses may occur, are covered with two courses of sponge felt block 1½ in. thick. With this superior insulation, it is expected that the radiation losses will not exceed from 2 to 4 per cent of the heat liberated in the firebox. The insulation is covered with a steel jacket which gives the locomotive an almost unbroken surface and a stream-line

GEAR-ROLLING centering device, on lead truck. Valve chests and piping



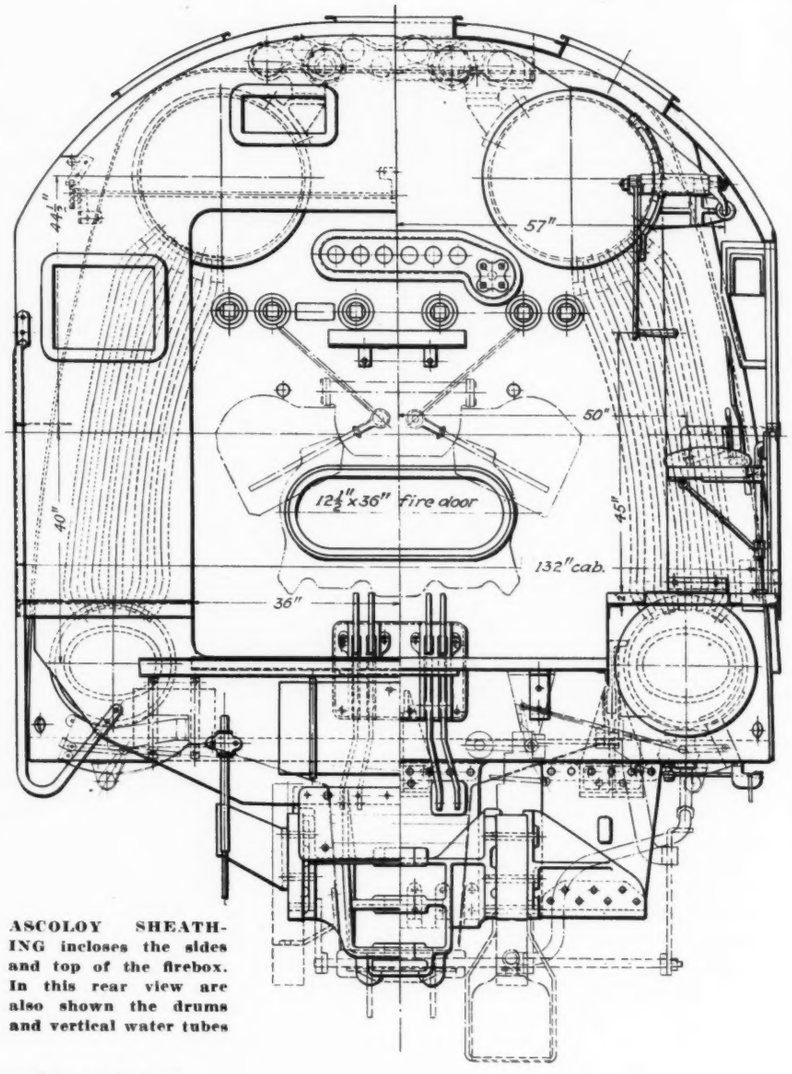
effect from the smokebox front to the rear of the tender.

The lead truck of the locomotive is an Alco cast steel outside bearing engine truck, with gear-rolling centering device. The purpose of this lateral-motion device is to equalize the rail pressure between the leading truck and the forward driving wheels. This improves the guiding and riding qualities of the locomotive and reduces wheel and track pressures, stresses, flange and rail wear.

A Dabeg type of mechanically actuated feedwater pump is driven by the crosshead. The one cylinder pumps the water from the tender tank into the exhaust steam feedwater heater and condenser, and the second cylinder pumps the water from the heater into the boiler. No live steam is directly used in this operation.

A MECHANICAL force-feed lubricator, on the right of the engine and driven by the valve motion gear, feeds lubricant to the cylinders, valve chests and main driving boxes. The lubrication of the journals of the main driving axles is obtained by an Edmonds oil-soaked felt pad retained against the bottom of the journal by a perforated plate located in the driving box oil cellar.

The locomotive engineer's cab is fitted with an instrument plate on which are located steam gages for recording the boiler pressure, the throttle pressure, the pressure in the high-pressure cylinder branch pipe, the receiver pressure and the exhaust pipe pressure, also dial thermometers to record the temperature of the raw and heated feed water, and two indicating pyrometers which register the temperature of the dry saturated steam and of the superheated steam. Additional gages record the air-brake pressures and the pressure of the steam furnished to the auxiliary locomotive located under the tender. There is also a locomotive speed indicating and recording gage. All of the cab fittings and appliances are conveniently located for the use of the engineer and fireman.

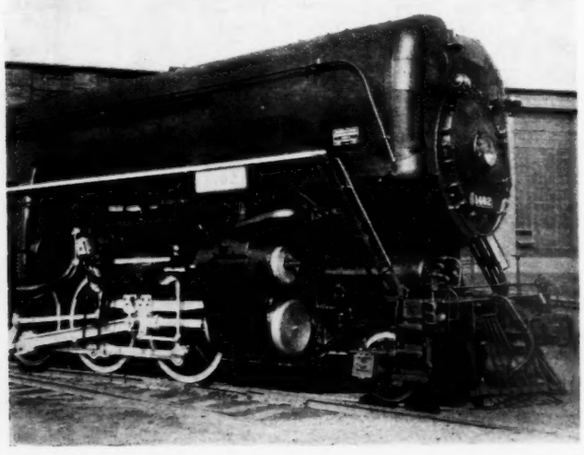


ASCOLOY SHEATHING incloses the sides and top of the firebox. In this rear view are also shown the drums and vertical water tubes

The boiler is hand-fired, and butterfly type fire doors which may be controlled by foot pedals in the floor, are used. An innovation is the ash-pan dampers, which are automatically operated with the opening and closing of the main throttle valve, but may also be opened independently. Grease lubrication is provided for certain parts, including the lubrication of the Barco flexible pipe joints.

The headlight is recessed in the smoke box door. On each side of the locomotive under the running board is an illuminated number box for displaying the locomotive's number.

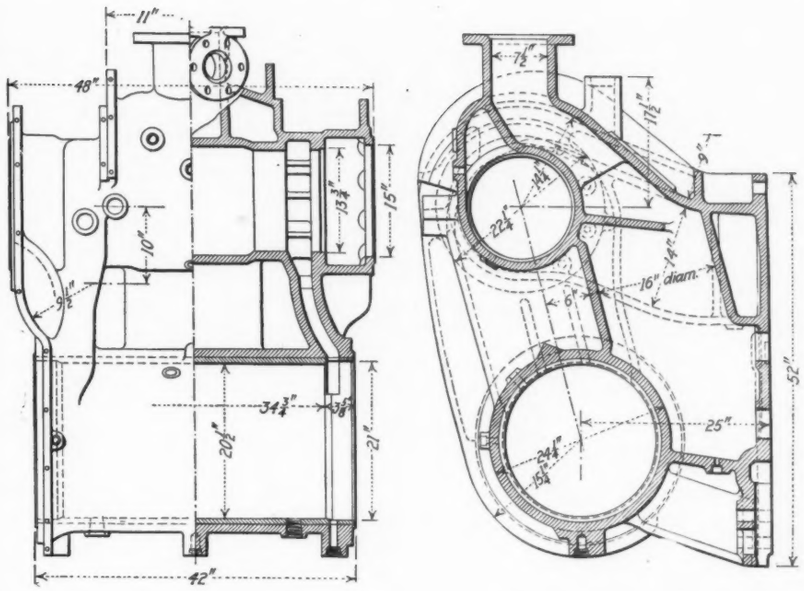
A good idea of the efficiency of the James Archbald can be obtained by comparing it with a modern conventional stoker fired locomotive using superheated steam at 200 lb. per sq.in. pressure. Such a locomotive with 63 in. diameter driving wheels, and having a tractive power of 70,000 lb. must supply live boiler steam to each of two 28½ in. diameter single expansion cylinders having a 32-in. stroke. In the James Archbald, with the same diameter driving wheels and engine stroke and producing the same tractive power, live steam is fed to only one 20½ in.



THE HEADLIGHT is recessed in the smoke box door and individual illuminated number boxes are located on the sides under the running boards

diameter cylinder. Comparing the amount of fuel required, to perform a given amount of work the James Archbald, with an overall thermal efficiency of 11 to 12 per cent, consumes only one ton of fuel to every three tons burned in the conventional 200 lb. pressure, superheated steam locomotive.

It must not be thought that this locomotive will hold its outstanding position for any great length of time. Locomotive design has entered another period of intensive development. With improvements that the railways are making on their main line roadways, there is no good reason why steam passenger locomotives and rolling stock should not now be designed for speeds of 125 m.p.h. Such speeds will afford much more intensive competition with airplane and airships, and highway motor-trucks and buses. With a high pressure type of steam locomotive with a relatively small diameter of cylindrical shell to obtain a low center of gravity, with 500 lb. per sq.in. steam pressure and 850 deg. F. total temperature, a modified uniflow system of steam distribution, and 90 in. diameter driving wheels, such high speeds can be readily obtained.



HIGH PRESSURE cylinder and valve chest casting with gun-metal cylinder bushing in place

In conclusion Mr. Muhlfeld brought out that when Mr. Loree, president of the D. & H. company, was president of the Baltimore & Ohio Railroad, in 1903, he made possible the construction of the first Mallet type—then the largest locomotive in the world—i.e., B. & O. 2400 (now B. & O. 7000), which even then carried 235 pounds boiler pressure and had over 80,000 pounds tractive power. It was exhibited at the Baltimore & Ohio Centenary in the fall of 1927. As a result of this development there are now about 3,500 Mallet type locomotives in use on between 75 and 100 of the steam roads in the United States, contributing substantially to the earning capacity of many of the largest railroad systems.

Subsequently, Mr. Loree as president of the D. & H. company made possible the development of more efficient, economical and high powered steam locomotives, through increased steam pressures and temperatures and the application of various capacity producing and fuel saving devices. These are represented by the locomotive described in this article. The employment of such locomotives has resulted in a high average revenue freight train load and lower transportation expenses, which are major factors in economical railroad operation under the existing extremely low revenue freight rates.

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A DECIMAL EQUIVALENT CHART

By James G. Turton
Heald Machine Company

IN CHECKING drawings it becomes frequently necessary to refer to decimal equivalent tables, and such tables, consisting as they do of fractional and decimal dimensions, cause considerable eye-strain and mental deflection from the problem in hand. To overcome this I developed the attached chart, and found that it proved a time saver. The upper part of chart is for use when fractional dimensions are to be converted to decimals, and the lower part for obtaining fractional equivalents to decimals.

For convenience, the decimal point preceding the first figure of each number in the body of the table, has been omitted. The numerator of the fraction is given in the top horizontal line, the denominator in the first column. Use the lower group of decimals for converting from decimals to fractions.

DECIMAL EQUIVALENTS OF PARTS OF AN INCH

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CAMS and SPIDERS

for Intermittent Motion

By D. D. DEMAREST

Consulting Engineer

ONE OF the most commonly desired features of an intermittent motion is uniform acceleration and deceleration in the driven member. This uniformly accelerated and decelerated motion is readily obtained in the mechanism described, consisting of a spider and a cam. The time of acceleration need not be the same as that of deceleration, nor need both be the same type of motion, either uniform acceleration or harmonic motion being readily obtainable.

The mechanism consists merely of a cam and a spider. The cam rotates uniformly and gives the intermittent motion to the spider through rollers on the arms of the spider which engage with the cam. One set-up of this gearing is shown diagrammatically in Fig. 1, the spider carrying four rollers, and therefore making a quarter revolution with each revolution of the cam. During half a revolution of the cam it rotates the spider, and holds it fixed during the other half.

The design of this gearing to fit any particular application requires only shop mathematics and a little concentration, if the underlying principles are kept in mind. In laying out this gearing it is first necessary to establish the radius of the spider. This radius has always a definite relation to the center distance between the shaft of the spider and the cam. When the roller center lies on the line connecting the two shaft centers, as shown at C, Fig. 1, it is in a pocket in the cam and in this position the cam and roller act as a pin gear, and the angular velocity of the spider will be the maximum relative to the cam. For all other positions of the spider, the velocity of the spider will be less. Therefore, when a roller on the spider lies on the line joining the shaft centers of the spider and cam the radius of the spider must be such that at this moment the cam will give the spider the maximum velocity that is desired. This maximum velocity is determined by the type of motion that is employed. If the spider is to have uniform motion, the maximum speed will of course be equal to the uniform velocity desired. With uniformly accelerated motion, the maximum speed will be twice the average speed, while with harmonic motion the maximum speed is to the average speed as 3.1416 is to 2.

Given a particular problem the designer has a general idea as to the distance he can use between the cam and spider shaft, or an idea as to the radius of the spider that will handle the required load. He must also consider the size of the roller, for, as it is shown later, the size of the roller is limited in this mechanism and will sometimes, if made too large, necessitate a larger cam than would otherwise be used.

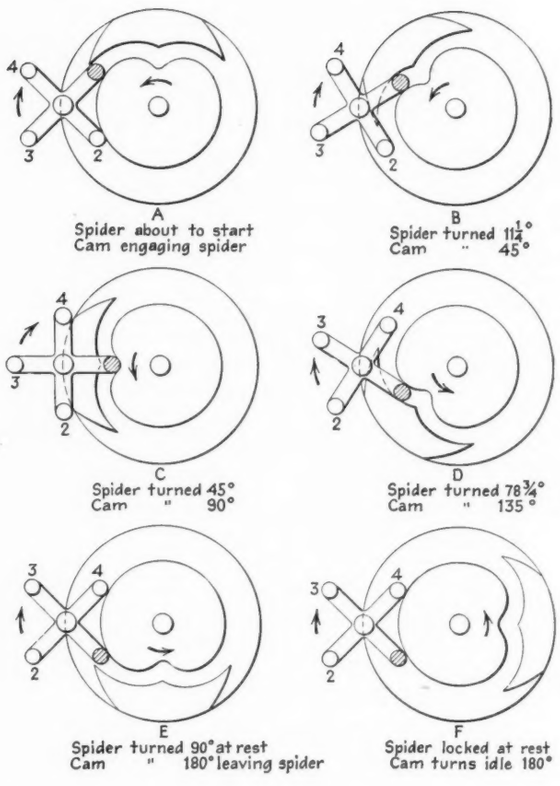


Fig. 1.
STAGES in a cam and spider intermittent motion

IN Fig. 2 are given the preliminary steps in laying out the cam and spider shown in Fig. 1. It is assumed that the motion is to be uniformly accelerated and uniformly decelerated and that a 6 in. center distance will be used between the spider and the cam shaft. With this type of motion the maximum speed is twice the average speed, and the average speed is determined by the ratio of the degrees through which the cam and spider, respectively, turn while they are both rotating. In this example the spider turns 90 deg. while the cam turns 180 deg., or the average speed of the spider is one-half that of the cam. As the spider has a maximum speed twice the average speed, then this maximum speed of the spider must be exactly equal to the speed of the cam, from which it follows that the roller will at this maximum speed point be equally distant from both the cam shaft and the spider shaft. This gives the spider a radius of 3 inches.

For the purposes of laying out the cam slot, it will be assumed that the camshaft stands still and that the spider shaft revolves around it at a distance of 6 in. In Fig. 2, *C* designates the camshaft and *S* the spider

shaft, with the roller centers indicated by X. The heavy X shows the roller about to enter the cam slot.

After 90 deg. of rotation the spider shaft has reached the position S_1. The roller center will then be just halfway between the shaft centers S_1 and C. The two roller center positions designated by X and X_2 determine the outer diameter of the cam. After 180 deg. of rotation the spider shaft has reached the position S_2 and the roller center, X_2, is now coming out of the cam slot. The size and general appearance of the cam can now be seen and if it meets the requirements the next step is to plot the cam path in detail.

IN uniformly accelerated motion the distances covered during successive equal time intervals are in the ratios as 1-4-9-16-25-36, etc., that is, the distance traveled is proportional to the squares of the elapsed time. Therefore, to give the spider uniformly accelerated motion it is necessary to divide its total movement so that at the end of equal periods of rotation of the cam the total rotation of the spider will be proportional to the square of the total movement of the cam; the latter motion being uniform is therefore proportional to the total elapsed time.

In this example the spider moves 45 deg. during acceleration and 45 deg. during deceleration. The cam rotates through 90 deg. while the spider is speeding up and through 90 deg. while it is slowing down. The motion of the cam can be conveniently divided in 10-deg. periods giving nine equal intervals for acceleration and nine for deceleration. The corresponding 45-deg rotation of the spider during acceleration or deceleration should be considered as composed of 9^2 or 81 units, divided as in the table below. Bearing in mind that the movement of the spider must be proportional to the squares of the elapsed time, which latter is measured by the rotation of the cam, the following table may be set up.

Movement of Cam	Movement of Spider
10°	1 x 45/81 = 0.5°
20°	4 x 45/81 = 2°
30°	9 x 45/81 = 5°
40°	16 x 45/81 = 9°
50°	25 x 45/81 = 14°
60°	36 x 45/81 = 20°
70°	49 x 45/81 = 27°
80°	64 x 45/81 = 35.5°
90°	81 x 45/81 = 45°

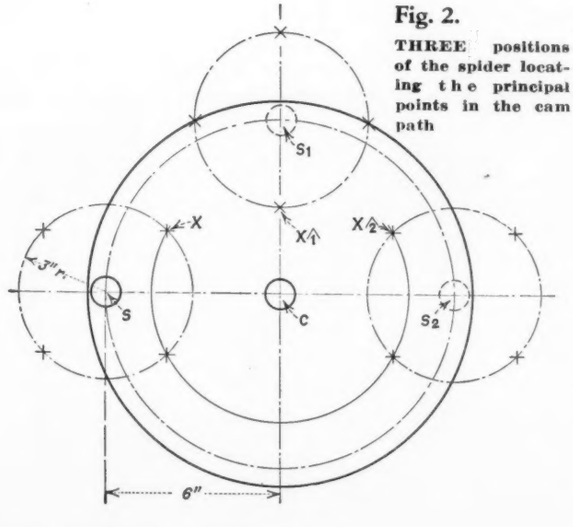


Fig. 2.

THREE positions of the spider locating the principal points in the cam path

The cam path may now be constructed as illustrated in Fig. 3. Radial lines at 10-deg. intervals are drawn out from the center C to intersect the 6-in. radius circle. At each of these intersections an outline of the spider is constructed as follows.

With each intersection as the center, draw a 3-in. radius circle and then lay a protractor on this circle with the center of the protractor at the center of the circle and the 90-deg. mark on the protractor pointing toward the center C. Then turn the protractor through the angle indicated in the table for the designated radial line and mark the 45-deg. point. These points projected towards the center of the spider to the 3-in. radius circle determine at the intersection the location of the roller centers and thus the roller can be drawn in. The same operation is repeated for each 10-deg. radial line until the position S_1 has been reached. Then starting at S_2 the same process is repeated, working back to the center S_1.

The path of the roller shown in cross section in Fig. 1

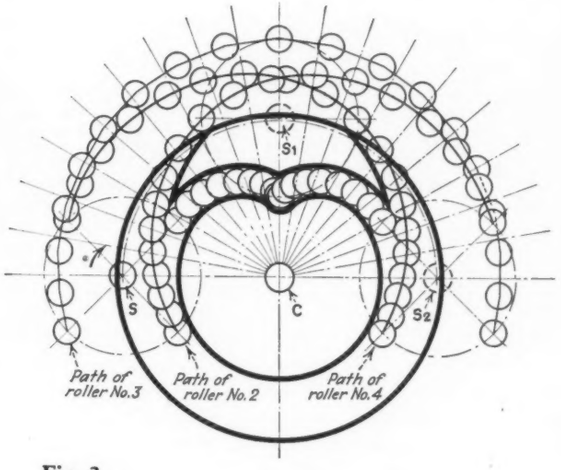


Fig. 3.

LAYOUT for constructing cam and cam slot

is marked in Fig. 3 by the X in the center of the roller in its various positions as it passes through the cam slot. But as shown in Fig. 1 the two adjacent rollers on the spider also touch the cam in places. The roller number 2, ahead of the shaded roller, rides along the outside of the "anchor" during acceleration, and the roller number 4 rides along the outside of this "anchor" during deceleration. The points of this "anchor" are determined by the intersection of the paths of these rollers and if the rollers are too large these points are cut away. The remainder of the cam is a part of the circumference of a circle, as shown in Fig. 3.

The minimum diameter of the cam is such that when the spider is at its mid-point, position C, Fig. 1, the cam will be tangent to the rollers 2 and 4 on either side of the roller in the cam slot. If the diameter of the circular portion of the cam is less than this there will be a time when the spider is not under the complete control of the cam and a certain amount of back lash will result.

Other designs of this mechanism, regardless of the number of rollers used on the spider or the type of acceleration or deceleration employed, are laid out in the same manner.

DISK CLUTCH DESIGN

Applications for machinery

By GEORGE E. POPE

Engineering Department, Raybestos Division, Raybestos-Manhattan, Inc.

AUTOMOTIVE clutch design is so highly developed that, despite severe usage, clutches of this class show remarkable durability, smooth engagement, and uniformity of operation, even in the hands of the careless user. The automotive industry has tried many types of design: fabric or metal band types in oil; cones, dry and in oil; multiple-disk, plain and with inserts in oil; and dry multiple-disk and single- and double-plate types. It can hardly be said that the design of clutches for machine tools has reached universally a corresponding state of development.

The evolution of clutch design in the automotive field from the early types having many parts and cumbersome construction, with short life and frequent adjustments, to the modern types, has been based upon and made possible by improved friction facing materials.

Sometimes it is not fully realized that most clutches are essentially energy absorption devices with their capacity, in the last analysis, limited strictly by their ability to absorb and radiate heat. The temperature of the friction surfaces largely determines the life and pulling power of the friction facings, and it is in their ability to withstand higher pressures and temperatures that friction materials of the latest types have contributed so largely to the simplification of clutch design. In fact, they have made possible the modern clutch.

Inasmuch as clutches, especially in machine tools, are usually fully enclosed and the circulation of air or oil is quite limited, the thermal capacity is a factor in design to be given serious consideration. The temperature of the friction surfaces, under any particular set of operating conditions is controlled by the heat absorption capacity of the metal plates or contact members, and by the radiating ability of the clutch as a whole. Since in most enclosed designs the ability to radiate heat to the surrounding medium is small, the capacity of the metal parts to absorb heat is often the vital factor in the design.

Other factors controlling temperature are: (1) Area of the engaging surfaces, (2) unit pressure on the engaging surfaces, (3) frequency of engagement, (4) percentage of slippage before full engagement takes place. The first two of these factors can be controlled in the design, whereas the last two can not and can only be estimated, the last one especially so with clutches in which the engaging pressure is applied by hand or foot.

The probable maximum operating temperature of the friction surfaces is, therefore, the unknown and practically indeterminable quantity in clutch design. For this reason the selection of a standard clutch, or the design of a new one, intended for a new machine, or even for a new location in a well tried machine, should be undertaken with care and with a knowledge of the effect that operating temperatures will have upon its daily performance and life. When the clutch is to be used under conditions that are not identical in every respect with some former experience of the designer it is well to be guided by successful designs used under conditions as nearly similar as it is possible to find.

In the design of disk clutches maximum torque capacity in lb.in., is expressed by the equation above at right.

A diagram showing dimensions and other factors is given. The mean radius equals one-half the sum of the inside and outside radii of the friction disk. The number of engaging surfaces, N, equals the total number of driving and driven disks, including the end pieces with engaging faces, minus 1, or N = total disks — 1.

When engagement and disengagement takes place there has to be a slight axial movement of the sliding disks. When there is no load on the disks this resistance to sliding on the driving teeth or keys is slight, but as engagement takes place the resistance to sliding becomes

MULTIPLE-DISK clutch designed for milling machine applications

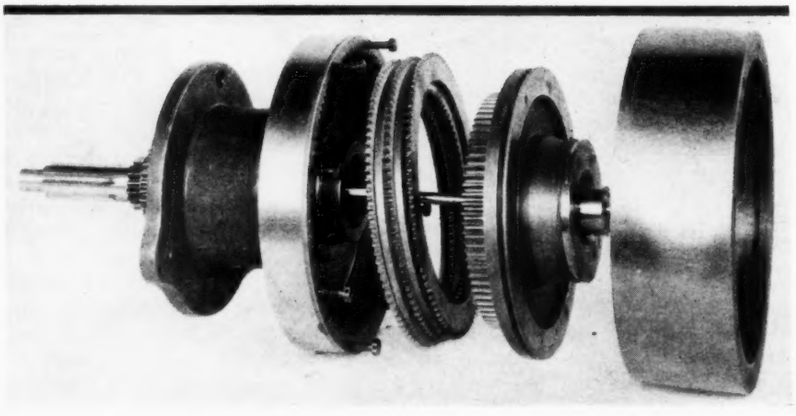
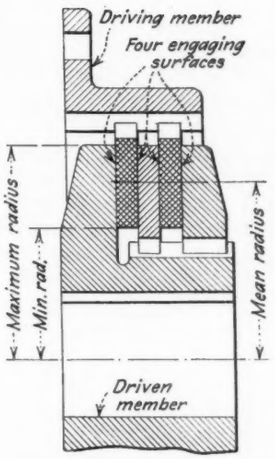


DIAGRAM of a double-plate clutch



Torque capacity (T) = $RPNf$

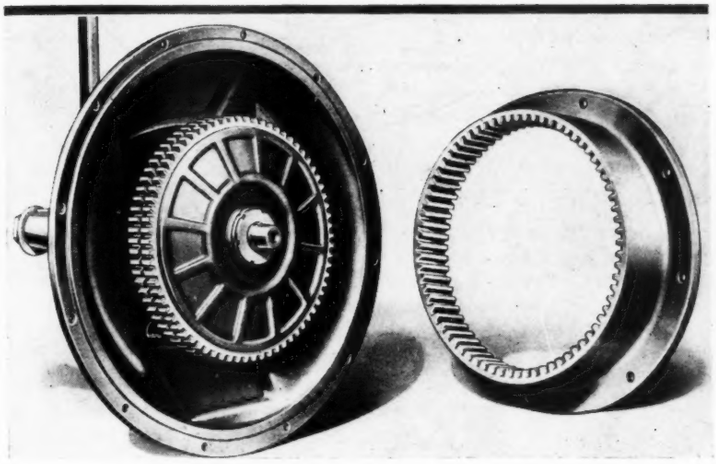
R = the mean radius of the engaging surfaces, in inches

P = the total normal pressure in pounds

N = the number of engaging surfaces

f = the coefficient of friction of the engaging surfaces.

BROWN-LIPE clutch for heavy machinery. The Raybestos disks are ⅝ in. thick



an appreciable quantity. In dry clutches, therefore, it is necessary to consider the total pressure, P, as being reduced by about 10 per cent for one sliding disk. The percentage loss increases up to 65 per cent for 10 or more disks. For clutches running in oil the above estimate of losses can be reduced considerably.

This key friction loss is increased if any appreciable misalignment of the disks is possible, and also in the case in which thin steel driving disks are used and cut slight depressions in the driving members.

Taking account of this loss in the above formula the effective torque, T, is expressed by the equation:

$$T = kRPNf$$

in which k is a factor the value of which depends upon the key friction.

AMONG other factors to be considered in clutch designs are several relating to friction and the behavior of asbestos friction materials: The static coefficient of friction is always higher than the kinetic coefficient. The coefficient of friction depends upon the kinds of materials and the nature of the surfaces in contact, but is independent of the area of surface in contact, within reasonable limits of change, and is independent of the rubbing speed, except for very low as against very high speeds.

The coefficient of friction changes if foreign matter, such as grease or dirt gets between the contacting surfaces. When, with lubricated materials, a film of oil or grease is retained between the surfaces, the coefficient of friction is largely independent of the character and nature of the friction materials, but varies with the quality and especially with the viscosity of the lubricant. If the unit pressure is sufficient to squeeze out the film of lubricant, the coefficient of friction usually rises suddenly as the oil film disappears. The coefficient of friction usually changes with a change in temperature of the sliding surfaces and with an increase of unit pressure, the latter principally because the heat developed when slip occurs is greater per unit of area and therefore the temperature is higher under any fixed set of conditions.

Most metals expand as their temperature rises, but most so-called "molded" asbestos friction materials have very little expansion with increase in temperature, up to their break-down temperatures; not more than one-tenth that of cast iron or steel. Asbestos fiber does not lose its combined water and its fibrous character until temperatures between 800 to 1,500 deg. F. are reached. Between 800 and 1,000 deg. F. the rate of change is very slow so that even at 960 deg. F. molded asbestos facing is a very durable material.

FRICTION materials of asbestos fiber are poor conductors of heat. A metal plate kept at 500 deg. F. in contact with one side of an asbestos friction clutch disk will raise the temperature of another metal plate, surrounded by still air and in contact with the other side, from 70 deg. to about 225 deg. F. in twenty minutes.

Most molded asbestos clutch disks are very resistant to compression. One relatively dense type, at room temperature, requires a pressure of 7,500 lb. per sq.in. applied for one-half minute to show a compression of only 0.001 inch.

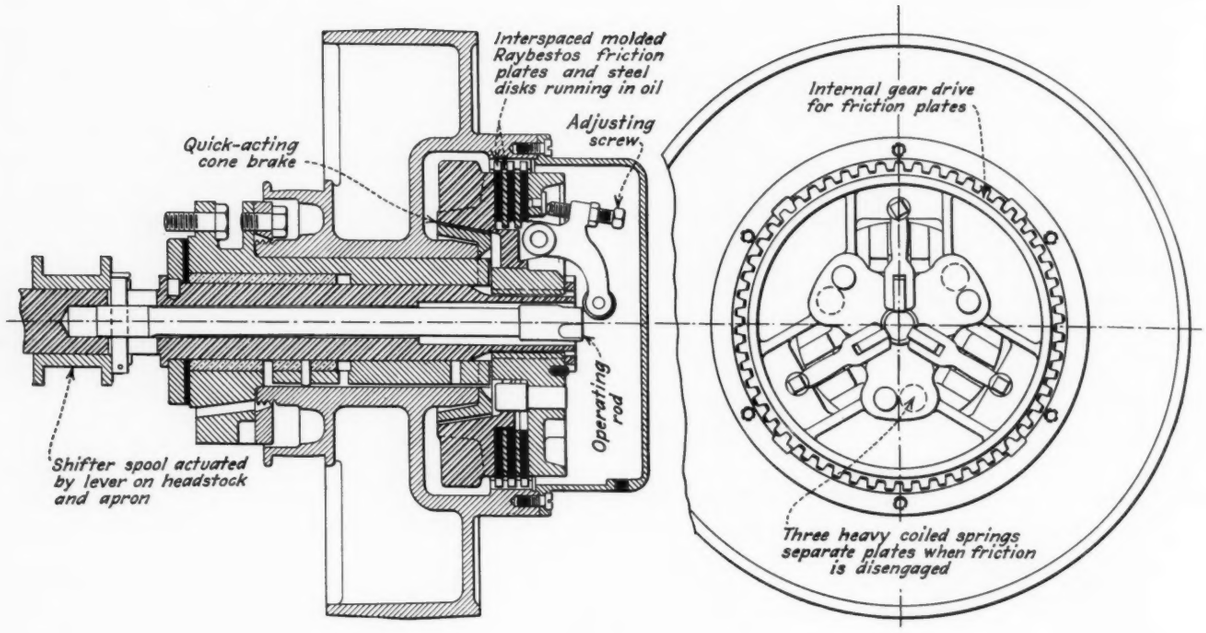
Heat radiation through the rough surface of cast iron (as from the foundry) is about five times greater than when the surface is polished. At operating temperatures between 600 deg. and 700 deg. F. low carbon steel sometimes abrades and roughens, whereas cast iron polishes smooth in contact with asbestos friction disks. If the temperature of the interior metal contact plates is likely to rise as high as 500 deg. F. and they are to be made of steel, they should have a carbon content of at least 70 points. The so-called "saw" steels are very satisfactory.

Some of the characteristics of clutch friction materials, both dry and in oil, are indicated by the following examples:

A molded disk of the facing type, for dry clutches only, was subjected to constant slippage for 30 min. between cast iron plates, at a pressure of 20 lb. per sq.in., the linear slipping speed on the mean radius being 1,770 ft. per min. The temperature of the contacting plate was 70 deg. F. at the start and 1,020 deg. F. at the finish. The coefficient of friction was 0.39 maximum and 0.30 minimum.

A molded disk, for dry or oil clutches, to be used as facing or as non-reinforced drivers, was subjected to constant slippage for 10 minutes between dry cast iron plates at a pressure of 15 lb. per sq.in. and a linear slippage speed, on mean radius, of 1,770 ft. per min. The temperature of the contacting plate was 70 deg. F. at the start and 860 deg. F. at the finish. The coefficient of friction was 0.30 maximum and 0.20 minimum.

When the same disk was immersed in oil of 133 Saybolt viscosity at 210 deg. F. and was subjected to


Interspaced molded Raybestos friction plates and steel disks running in oil
Adjusting screw
Quick-acting cone brake
Internal gear drive for friction plates
Operating rod
Shifter spool actuated by lever on headstock and apron
Three heavy coiled springs separate plates when friction is disengaged

MULTIPLE-DISK clutch used on R. K. LeBlond lathe head

constant slippage for 30 min. between cast iron plates at a pressure, 60 lb. per sq.in. and a linear slipping speed, on mean radius, of 1,228 ft. per min., the temperature of the contacting plate rose from 70 deg. F. at the start to 236 deg. F. at finish. The coefficient of friction was 0.18 maximum and 0.08 minimum. The wear on the friction disk amounted to 0.003 inch.

When an exact duplication of the foregoing test was made with a bronze disk in place of the asbestos material, but with oil, and unit pressure and slipping speed identical, the test was stopped at the end of ten minutes because the bronze disk commenced to gouge and strip its surface. The coefficient of friction was 0.06 at start, 0.35 at finish and the wear of the bronze disk, 0.050 inch. The temperature of the contacting plate was 70 deg. F. at the start and 350 deg. F. at the finish.

WITH this data it should be possible to evolve a practical clutch for any purpose, having due regard to those factors in operation that are indeterminable except by experience under identical or similar conditions. Since all the elementary design factors are independent variables, the proportions of a clutch for any particular conditions are widely variable. In practice, however, there are limiting conditions that control each factor. These may be stated briefly as follows:

Since the torque capacity of the clutch increases directly as the mean radius, it is desirable to make the mean radius as large as possible. This dimension, however, and, of course, the outside diameter of the clutch, usually is limited by the space available. Another limitation is the spinning inertia, which increases directly as the square of the effective radius.

✦

BASIC FACTORS affecting the pulling power and life of different types of disk clutches include heat dissipating capacity, permissible operating temperatures, friction between engaging surfaces, speed and spinning inertia, engagement pressure, wear, adjustments, and many other items. All of these items are interrelated

✦

The normal pressure per square inch is limited by the character of the friction materials and the thermal capacity of the clutch. For any particular friction material the unit pressure can be increased if and when the thermal capacity is increased, within a reasonable amount. In respect to this factor the designer should be guided strictly by experience. The number of engaging surfaces is limited by thermal capacity, for the innermost disks usually are in a poor position to radiate heat. Complication of construction and high cost also limit this factor. The coefficient of friction is limited strictly by the kind of materials used and their operating temperature, or by the lubricant if the clutch operates in oil. Thus, in three out of four design factors the thermal capacity appears as a controlling limitation.

IN otherwise similar conditions of operation, the wear of the friction elements per engagement is proportional to the temperature of the friction surfaces, to the rubbing speed, and to the unit pressure. Therefore, the following questions should be answered before the practical design of a dry clutch is started. Can a reasonable amount of wear be allowed by providing accessability and ease of adjustment, or must the wear be kept to an absolute minimum for converse reasons. What is the maximum allowable unit pressure and maximum and minimum coefficient of friction obtainable in a suitable friction material? What mean radius can be adopted? How many disks is it advisable to adopt? If the driving keys or teeth are to operate directly on the friction material, what pressures per tooth can be allowed?

In the design of a clutch to run in oil all of the above factors should be considered and in addition the range in viscosity of the oil under the minimum and maximum operating temperatures should be known. It should

also be known whether the oil film will be squeezed out so as to permit direct contact of the materials under the maximum pressure and temperature met in service.

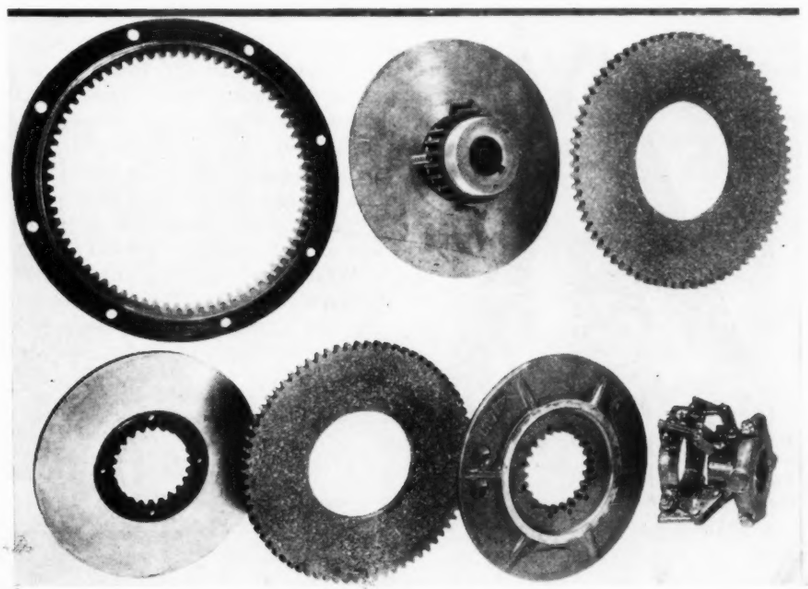
A MATERIAL of hard, dense structure, with a tensile strength of 5,000 lb. per sq.in. is available for clutch friction disks to be used without reinforcement for drivers, either dry or in oil. The development of this type of material permitted a marked improvement in clutch designs especially for industrial and machine tool purposes, along the lines of greater simplicity, reduced cost, and increased life. The driver type of friction disk, as at present developed, takes advantage of the fine fits and close indexing possible in the generation of gear teeth, thus distributing the driving pressure evenly over a large surface. A material suitable for this construction should carry safely a pressure of 50 lb. per in. width, per tooth, for the six- to nine-pitch stub tooth generally used.

An excellent example of a clutch designed for use is that in the R. K. LeBlond lathe heads. This clutch incorporates the sturdy simple lines of clutches used in automotive applications. It runs in a bath of oil fed in a continuous stream from the headstock. The dense, long-wearing friction disks permit a fine, sensitive control by a lever on the headstock and apron. The cone brake incorporated in this design automatically comes into action through the pressure of three coiled springs, which also positively separate the disks when the clutch driving pressure is released by the operator. The action of this clutch is powerful, but sensitive and smooth. Adjusting screws are reached easily when required, but the wear of the friction disks, under ordinary usage, amounts to only a few thousandths of an inch after years of running.

Another successful clutch, using the integral-tooth type of driver, was specially designed, in various sizes, for use in the main drive of universal milling machines and employs three heavy friction disks with teeth cut in their periphery. The metal driven disks are iron castings of heavy section and are capable of generous heat absorption. This clutch also is used in conjunction with a cone brake, a combination that provides the operator with a quickly responsive and sensitive control of the movement of the main drive spindle. The design and construction are of high quality and the clutch has been applied successfully to a number of types of milling machines of a well known make.

ONE important line of industrial clutches utilizes extra-heavy (some are $\frac{5}{8}$ in. thick) asbestos friction disks with integral driving teeth cut in their periphery. These clutches are suitable for use in power shovels, road rollers, cranes, hoists, graders, industrial locomotives, and industrial power units generally. The requirements of a clutch in such services are usually quite severe and this type of construction, using a hard, dense, long-wearing type of friction element, has proved highly successful. This construction combines ease of assembly, freedom from mis-alignment, long life, and quiet operation.

Other industrial clutches that are manufactured regularly have friction disks of the heavy toothed type. All parts are strong and have generous heat absorbing capacity. These clutches are easily installed and easily adjusted and have long life under heavy duty.



TWIN-DISK clutch designed for heavy duty

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Draftsman's Scales

By F. B. Faulkner
International Nickel Company

My first drawings were always made with a triangular scale. One day I read in a technical magazine that the flat scales were better. I bought a flat scale, and since that time have been using them constantly. They are less in the road and it is easier to pick out the scale you are using after laying it down and moving it around. It is interesting to note that drafting machines use flat scales.

The first flat scale I purchased had a half and full size scale on one side and 3 in. and $1\frac{1}{2}$ in. to the foot on the other side. This latter was exactly like Professor Guillet's shown in the illustration of the second face, in the March number. However, on two occasions I mistook the 31-in. mark on the quarter scale for the 32-in. mark on the one-eighth scale, both of these scales being on the same face. This is an easy trap to fall into, because the two scales run together about $7\frac{3}{4}$ in. from the zero end of the quarter size scale. Of course, the possibility of making such errors could readily be eliminated by simply having separate individual scales.

I resolved to get separate scales, and I had them made special to my order at a very reasonable price. These special scales were in cross section like a parallelogram with an acute angle of about 30 deg. Only one scale appeared on each of the two narrow faces. One scale was made up with half and full size scales, and another had the quarter and eighths.

As regards the $\frac{3}{8}$ in. scales and the $\frac{3}{4}$ in. scales, they are odd sizes and not necessary on any new work. For scales smaller than one-eighth size I always use either 1 in. to the foot or $\frac{1}{2}$ or $\frac{1}{4}$ or $\frac{1}{8}$ in. scales. I see no good reason for scales of $\frac{3}{4}$ in. per foot.

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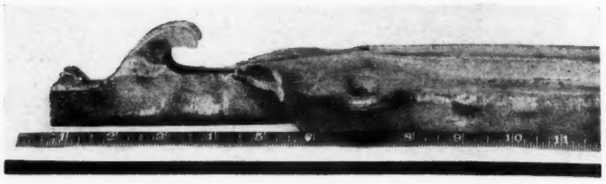
Malleable Iron Castings



Some Design Precautions

By FRANK J. OLIVER
Western Editor

THERE are certain inherent characteristics of malleable foundry practice that make it highly necessary that castings made in this way should be properly designed from the foundry standpoint as well as from the standpoint of their function in the machine of which they will become a part. Only in this way can efficient and economical production of malleable castings be obtained.

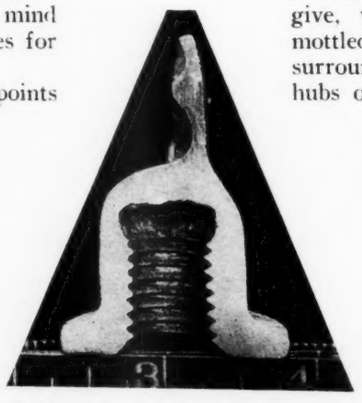
In the first place it should be remembered that in the initial stage, the malleable casting is in the form of hard, white iron with almost all the carbon in the combined state. In order to produce this condition rapid cooling is necessary, and hand in hand with rapid cooling comes severe shrinkage, which, unless properly provided for, results in a high proportion of scrap from shrinkage cracks. Proper gating, though primarily a matter of foundry practice and hence, at first thought, outside of the scope of this article, is nevertheless related to design in that the designer must keep in mind the provision for gating and in some cases for the use of risers.

Shrinkage cracks will often develop at points where there is a quick change of section. It is therefore desirable to make the stock of the casting as uniform as possible, and to avoid having heavy sections connected directly to light sections. Where a wide variation in section thickness is unavoidable, there should be a gradually increasing thickness in the wall joining the thin and the heavy sections, thus avoiding shrinkage cracks.

Heavy sections or bosses surrounded by light sections make it impossible to secure proper feeding, resulting generally in unsoundness. This trouble can be overcome by placing ribs of sufficient section on light parts to permit proper feeding. The location and size of ribs should be such that they can be properly fed, or if connecting light and heavy sections, the ribs should be of such section that they can be used to feed metal through to the heavy section. Where heavy sections such as bosses or lugs are located on an interior portion of a casting, the casting should be so designed as to provide heavy sections of metal leading to the feeding source, or else some provision should be made to feed these heavy sections separately. Cross-sections, such as ribs forming a cross, however, should at all times be avoided.

A design, with predominately thin sections, with here and there a very heavy hub or boss, will often give, with any ordinary silicon content, a mottled iron, not only in the hub but in the surrounding area, especially if two or more hubs or bosses are placed near together. In such cases, to prevent mottling, hubs should be designed to be cored out or else designed so that they can be chilled. The trouble with mottled iron is that it will not anneal properly.

When considered from the point of view of properly gating the casting, the design must be made heavy or thick enough to permit adding a



HEAVY gates and risers are necessary to produce sound castings, and reduce losses. This is a fragile piece in the white iron state, and until annealed, requires special handling

A DIFFICULT design to produce in malleable iron, since shrinkage cavities form at the junctions of the heavy lugs and the relatively light cross member

AS FIRST designed, this casting was made without the reinforcing webs above the notches, and failures of perfectly sound pieces occurred under shock conditions because the notches tended to magnify the impact stresses. The addition of the webs solved the difficulty

From a Study Made by the Malleable Iron Division, American Foundrymen's Association

ALL TYPES of gating failed to relieve shrinks where the horizontal section is attached to the deep vertical section behind the eyes. Increased section above these eyes at two local points, eliminated shrinks

BY PADDING the clevis core to make the depression, and the pattern to enlarge the section, better feeding was obtained and shrinks were entirely removed

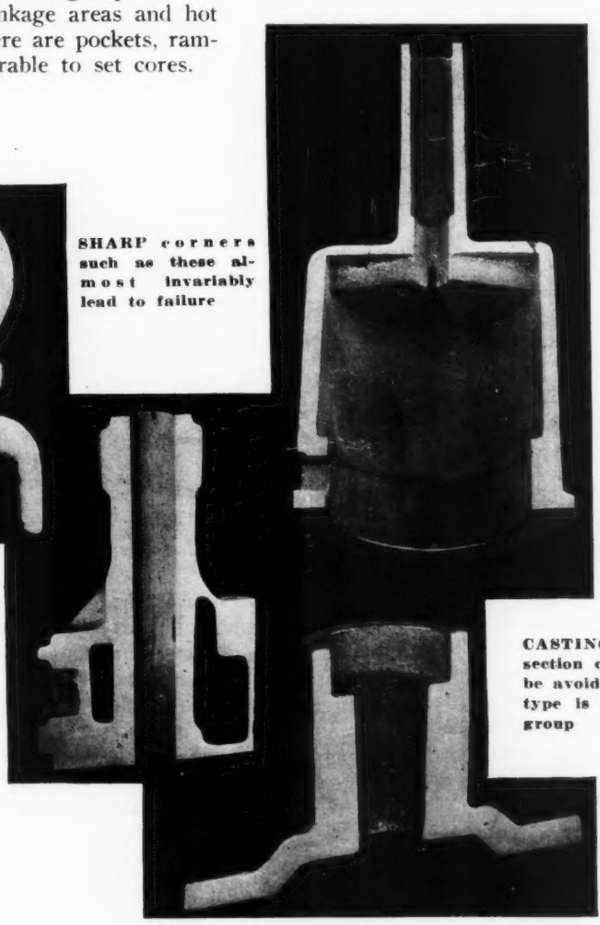
gate of such a size as to insure good feeding of all sections; that is, provision should be made for attaching gates and feeders at suitable places.

In any type of casting, sharp corners should be avoided and the fillets should be kept as large as possible. Round corners and large fillets make molding easier, result in less scrap from shrinkage, and less the danger of the sand being cut away by flowing iron. The only place where sharp corners help in molding is where they come on the parting line. Incidentally, parting lines should always be made as even as possible, so that it is necessary for the designer to have in mind just how the pattern is to be molded.

In design where cores are required, if possible, the design should allow for green sand cores, especially where the casting must contract upon cooling. Green sand cores are preferable to dry sand cores because they eliminate core making expense and do away with shrinkage areas and hot cracks. Where there are pockets, ram-up cores are preferable to set cores.

REDESIGN eliminated the shrink holes in the heavy section of this casting. A spur was added to the core giving an even section right out to the edge of the flange

SHARP corners such as these almost invariably lead to failure



PADDING the core to produce the conical-shaped depression, relieved the heavy section and eliminated shrinkage cavities midway between the pin hole and core cavity of the casting above

Designs should be such as to provide ample draft for easy molding. All deep pockets and small recesses that would complicate drawing the pattern or lifting the cope should be avoided as far as possible.

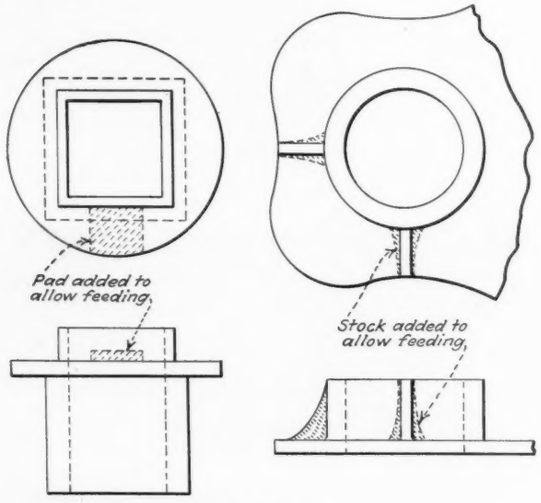
Sufficient amount of "finish" should be allowed when castings are to be machined, giving consideration to the size of the castings and the machine set-up to be used. Dimensions which have no finish and are to be held to very close limits should be considered as the proper place to centralize when developing tooling fixtures.

When castings are to be machined,

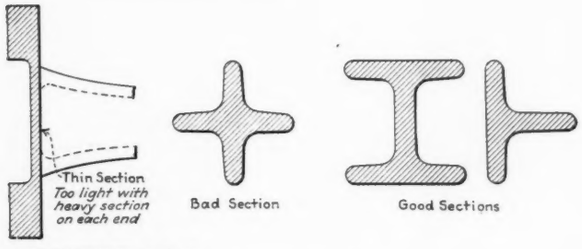
CASTINGS with wide variations in section caused by solid bosses are to be avoided. An oil jack body of this type is shown in the center of the group

PRACTICALLY impossible as it is to feed the central hub through the thin flange, there is no other economical way to do the feeding. A thicker flange or feeding through a rib would be more practical

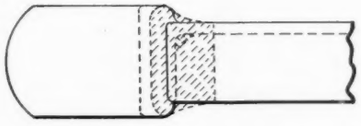
the blueprints sent to the pattern maker should always show machine shop locating points. Otherwise, the pattern maker will either not consider these points in the construction of the pattern or else use his own judgment, which may often be wrong. Furthermore, locating points should be held to one side of parting line to eliminate trouble in machining. Proper attention to these items will usually save a very considerable amount in tooling expense, cost of machining or scrap losses, particularly in quantity production.



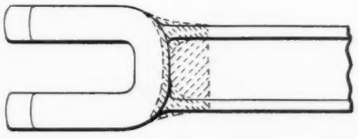
PROVISION must often be made in the pattern for properly feeding sections of the casting that run out from the main body



EXAMPLES of bad and good sections in malleable iron castings

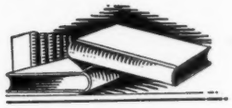


CRACKS caused by too rapid change in section can be eliminated by adding fillets to make the change more gradual



Tolerances on unfinished casting dimensions are often held too close. In this connection it must be realized that differences in carbon content affect expansion during annealing and hence size in the ultimate casting. Large scrawlly designs for malleable iron should be avoided on account of liability of troubles from misruns and cracks during foundry process and in annealing with subsequent difficulties in straightening.

Books for Engineers



LECTURES ON STEEL AND ITS TREATMENT. SECOND EDITION. *By John F. Keller, Engineering Extension Division, Purdue University. Three hundred twenty-nine 6x9-in. pages. Cloth board covers. Two hundred fourteen illustrations. Published by the American Society for Steel Treating, Cleveland, Ohio. Price $3.50.*

ALL of the chapters in this second edition have been revised and enlarged, and a chapter on alloy steels and gas and electric welding has been added. The lectures, essentially as contained in this book, were delivered to industrial groups throughout the state of Indiana, as a part of the extension service of Purdue University. The author, known among his friends as "The Learned Blacksmith," evidently has the abilty to express himself clearly in simple words. Beginning with a description of the processes and equipment involved in the manufacture of steel up to the billet stage, the author continues with a discussion on purchasing, inspecting, checking, marking and identifying steels.

The third lecture has special appeal to those who desire an acquaintance with the metallurgy of steel, but do not care to go deeply into the subject. In this chapter the author presents in a clear manner the iron-carbon diagram and the theory of solutions. The balance of the book deals with the determination of critical points, physical testing, heat-treating processes, and defects common to steel. Those who desire a fundamental knowledge of the manufactuing pocesses and the character of iron and steel, but do not wish to go into the highly technical aspects of the subject, will find this book of interest and value.

✦

MECHANICAL ENGINEERING LABORATORY PRACTICE. *By Charles E. Shoop, professor of steam engineering, University of Minnesota, and George L. Tuve, professor of mechanical engineering, Texas Technical College. Four hundred eighty-eight pages, 5½x9 in. Illustrated. Cloth board covers. Published by the McGraw-Hill Book Company, 370 Seventh Ave., New York, N. Y. Price $4.*

THIS book is written primarily as a college textbook for use in laboratory work. It deals almost entirely with the elements of power-plant machinery and the use and calibration of measuring apparatus, and presents the related fundamental theory. The methods for mechanical and thermal measurements and the instruments used, are described and explained. In addition to methods for testing steam engines, boilers and accessories, gas engines, and refrigerating plants, the book contains interesting information on oils, lubrication, and lubricating devices.

As stated by the authors in their preface, though intended primarily as a textbook, it may also be used as a reference book. An appendix of about fifty pages contains much valuable data and tables, including specifications on lubricating oils and a table of gas expansions and equations.

The Electron Tube

a modern design element

By O. H. CALDWELL
Editor, Electronics
Former Federal Radio Commissioner

LOOKED AT broadly, the importance of the invention of the electron tube can be compared only with Archimedes' discovery of the lever and his proud boast that, with an adequate fulcrum, he "could move the world!" For the vacuum tube is, in effect, an electrical lever; its grid input representing the short arm and its anode output the long arm. And just as the principle of the lever is used again and again in every element of every machine built in this mechanical age, so the introduction of the vacuum tube and its associated circuits presents almost inconceivable potentialities in the electrical future.

So rapidly are new electronic applications coming that, within a few years, one may safely predict that the tube will be a universal factor in everyday life, and nothing that the average man sees, hears, or buys but will be controlled, regulated, or affected in some important respect by an electronic tube.

A scrutiny of the list here shown must offer a powerful stimulus to any engineer in suggesting new uses and adaptations of thermionic or photo-electric cells in his own industry and in the solution of his own special problems.

Some Present Applications:

Motor Control

- Starting equipment
- Circuit breakers
- Frequency control for variable-speed motors
- Synchronizing equipment for two or more motors
- Source of high-frequency supply for high-speed motors
- Current regulators
- Relays, switches
- Elevator control for leveling
- Field control of generators

Industrial Applications

- Safety guards
- Counting, grading, sorting, inspecting
- Tabulating and automatic calipering
- Alarms—temperature, burglar, smoke, fire
- Process control
- Smoke indicators in plant stacks
- Smoke precipitators
- Measuring candlepower
- Lighting control
- Relays and elimination of contacts
- Light-controlled locks
- Detection of foreign objects
- Color matching
- Sensitive microphones
- Reversing-mill control in steel plants
- Source of oscillations for induction furnace
- X-ray analyses of materials and products
- Industrial heat control
- Control of secondary clocks
- Recording pressure cycles
- Continuous control of thickness and moisture
- Continuous weighing of sheet products
- Induction heating of inaccessible parts
- Dielectric-hysteresis heating of insulating materials
- Accelerating chemical reactions and processes
- Inspecting high-speed operations
- Pressure and level arms and controls

Entertainment

- Broadcast transmitters and receivers
- Sound picture projectors
- Binaural sound picture work
- Electric phonographs
- Automatic phonograph devices
- Musical instruments (Theremin-type)
- Vacuum-tube organs
- The "talking-book"
- Television transmitters and receivers

Train and Traffic Control

- Railway signals
- Automatic cab signals
- Street traffic signals
- Remote control
- Automatic traffic signals
- Voice control of car, boat, etc.

Communication

- Telephone repeaters
- Radio transmitters and receivers
- Broadcast transmitters and receivers
- Telegraph multiplexing
- Telephone carrier frequencies for multiple channel operation
- Carrier-current telephony over transmission lines, for despatching
- Public address systems
- Facsimile transmitters and receivers
- Beam radio transmission
- Radio program distribution
- Automatic conversation recorders
- Dictaphones for crime observation

Electric Power Transmission

- High-tension d.c. transmission
- Inverters, d.c. to a.c.
- Frequency converters and dividers
- Rectifiers
- High-tension switches
- Lightning arresters
- Generator-voltage regulation
- Transformer regulation
- Carrier-current dispatching over transmission lines
- Phase-control
- Synchronizing equipment
- Tele-metering
- Remote switching and control
- Relays and contacts
- High-voltage meters
- Detection of flashovers
- High-tension marker lights
- High-tension safety equipment and interlocks

Navigation and Aviation

- Radio communication
- Radio compasses and beacons
- Directional beams
- Landing systems
- Channel locaters and depth sounders
- Altimeters
- Photo-electric communication on light beams
- Supersonic sounding and signaling
- Automatic switching and control

Measurements

- Minute changes in temperature
- Minute electrical currents (10^{17} amp.)
- High-voltage voltmeters
- Frequency indicators
- Electrical resistance and impedance
- Tachometers
- Stroboscopes
- Integrating ultra-violet meters
- High-vacuum measurements by ionization
- Oscillographs for analyzing wave motion
- Foot-candle meters
- Color analysis
- Energy analysis of spectrum
- Traction dynamometer
- Pressures, explosion
- Mechanical measurement to one-hundred millionth inch
- Moisture determination
- Metering gas in large quantities

Lighting

- Control of illumination by automatic switching
- Remote switching
- Gaseous conductor signs
- Current source—for gaseous signs in d.c. districts
- Theater dimmers
- Sign flashers

Metallurgy

- Source of oscillations for induction furnaces
- Automatic temperature control of furnaces
- Detecting flaws in steel
- Analysis of metal structure produced in heat-treatment
- Reversing billets in steel mill automatically by own shadow
- Controlling oil-well drilling

▶◀

THE ENGINEERING

The scene is a big contract production shop, consolidated also with an iron foundry and a nonferrous metal plant. It controls, also, a smaller shop that makes a specialty of contract production for the chain stores and mail-order houses. Conferences of the engineering and affected production executives with the chief engineer have grown into what the plant calls "The Engineering Council," which meets in a "council room" in the engineering department. Foremen are called in, and others drop

How Much Customer Contact for the Designer?

"THERE'S no argument to it," continued Roy Sellers, the general sales manager, "if we expect to keep abreast of our competitors in sales we must keep up with them in the design of our products. The Crawford people are now offering and selling their new machines completely redesigned with a lot of new features, while all that we have done was to put in a few ball and roller bearings. There is only one thing for us to do, that is to redesign our machines following the lines of our competitors, which will also mean lower manufacturing costs. How do you expect us to sell under present conditions?"

"Ray, I've told you before at least a dozen times," spoke up Art Levering, the chief engineer. "I won't redesign according to the Crawford machine. They sacrificed a lot of strength and quality and are using questionable construction. If we made such machines, they simply wouldn't last."

"If the Crawford people can do it, why can't you?" asked Sellers.

"They haven't done it yet," argued Levering. "Wait until those machines have been in service a few years and see what happens. No matter how you figure it, those new frames cannot stand up under the severe service to which they will be subjected."

"Well, do you mean to say, Art, that the Crawford people would put out a machine which they know will not stand up in service?" asked Sellers.

"I do not mean anything of the sort," said Art Levering heatedly, "the fact is, I am convinced that they have made a mistake, and I, for one, am not going to be railroaded into making the same kind of a mistake. As far as I am concerned, I know that for us to follow their lead may give us some immediate orders, but eventually would simply lead us into trouble. And then everyone would say, 'If the engineer knew it was wrong, why did he design it?'

"Right here let me say something more that has been on my mind. I think it is about time that this company recognize the fact that we cannot depend upon salesmen's reports entirely in planning our future engineering developments. What we should have are real engineers from the engineering or development department to go out and collect our information. They are the ones to interview the customers to find out how the machines are giving satisfaction, wherein they are not holding up, and report on the conditions to be met. As far as this present proposition is concerned, all I've got to say is 'Nothing doing.' I won't be a party to designing inferior machines just to meet the demands of the sales department."

"Now boys, let's not get too hot about this," spoke up Mr. Hedley, the general manager. "I suggest that you fellows talk it over among yourselves, and then the next time we get together we will be in a better position to consider this matter properly both in regard to the design problem, and to the question as to whether or not our engineers should have better contact with the customers."

Should good engineering design be sacrificed to meet competition? What are the dangers and advantages in having direct contact between engineer and customer?

COUNCIL

in. The problems are not solved for the readers, but some of the opposing opinions are brought out. Engineers and designers are invited to discuss the problem, or to present new problems for discussion. Acceptable letters are paid for at regular rates.

DISCUSSION
OF COUNCIL TOPICS

■

Use Combination Letter Symbols

MARKING of parts with the metal from which they were made is desirable, and in many instances, necessary. Of course, there are innumerable parts which it would be impractical to so mark.

I believe that if a standard code composed of two or three letters were used to designate the standard brands of steel, the most popular ones being designated by a two-letter code and the less frequently used by a three-letter code, practical results could be obtained.

The main thing is to *start* a code of this nature. Its application and general use will grow if it is really practical. A large number of manufacturers are today using individual codes of a similar nature on much of their product.

—E. J. Bryant, *Manager, Gage & Reamer Depts., Greenfield Tap and Die Corporation.*

■

Do You Still "Roll Your Own?"

GENERALLY, one can say that the pride of a shop in an article of its own manufacture is a relic of "old times," when manufacturers were forced to do all work in their own shops. Modern designers should not foster this pride. Elements of standard form can usually be used in a design at less cost for installation and replacement.

In order to insure the use of standard parts, we have installed a special drawing-control system, attached to the production department which is always in close contact with the construction department. In all cases where the use of a standard part has been neglected, the attention of the designer is called to his mistake by the controlling executive, a well-trained engineer. He also ascertains the price of the standard part from the purchasing department, and with this information, decides what is to be done.

There are many factories producing standard parts which are perfectly willing to furnish the parts within specified tolerances to fit particular designs and to insure interchangeability. When special high-strength parts for a completely new and different design are wanted, however, the factory will do well to make them at home, and so absolutely insure security.

—Franz Bermann, *Consulting Engineer.*

■

Should Not Make Standard Parts

FOR THE DESIGNER, there are several things to be considered before reaching a decision in regard to buying or making special parts; the shop equipment, the number of parts to be made, the cost of material and labor, and the ability of the mechanics in the plant to make them with the desired accuracy.

It is not to be expected that men continually working on one type of product can make special parts as accurately as the manufacturer of the special parts. Neither can they make them as cheaply. If there are special parts to be made, the designer should take all of these facts into consideration when calling for these parts. In my opinion, in the long run, the designer will find it better from an economic standpoint to buy such parts.

—George H. Gunn, *Designing Dept., Naval Aircraft Factory.*

■

Improving Standard Products

READING the article "Shall We Buy or Make Parts" I was reminded of the story of the man whose wife was confined to the hospital. Every morning when he called he received the assurance that "Lena is improving." Finally he received the news that she had passed away. Later, when a friend inquired as to the cause of his wife's death he related about the daily hospital reports, and concluded "so I guess she died of improvements."

Many engineers in their enthusiasm feel that they can improve upon the products of the manufacturers of standard specialties. Probably they do not realize the years of engineering and manufacturing development that was gone through in order to bring the standard product to a high quality and low price.

Even though the engineer may have the necessary background and ability, and succeed in making an excellent design of a specialized product which is not made by his company on a production basis, the probability would be that his shop would not be able to properly translate the design into the finished product.

There is an old proverb which very aptly applies to this situation, namely, "Let the cobbler stick to his last."

J. A. Covington, *Consulting Engineer.*

■

Use Numbers for Materials

WE HAVE had many years of experience in the drafting room and believe that the use of symbols for designating materials is decidedly a step backwards. A symbol has no intrinsic meaning; it can mean anything. As long as we have a system of figures and the English language to fall back on, why should we go back into the dark ages and use symbols.

The proper way to get at this is to prepare a large drawing or a chart, giving each grade of steel or bronze, or rubber, or wood, or whatever it may be, a distinguishing number which means this and nothing else. With this number, should be fully described to the minutest detail the material in question. A division of the chart should have letters designating the various styles of heat treatment, so for instance a steel marked "36A" on the drawing would by reference to the chart give to the workman the fullest information regarding not only the material but its treatment.

The S.A.E. has designated many steels, and these numbers should be used as far as they go, and for any material they have not standardized on a number should be allotted. This takes the fullest advantage of the work which they have done, and avoids introducing a duplicate system of numbers.

In the stockroom, the steel should be painted with distinguishing colors or combinations of colors, either on the ends, or if the steel is to be cut up, over the full length. These colors should also be enumerated on the chart with the distinguishing numbers. I have seen this system in practical use in one of the largest automobile companies and it works well.

—C. N. Calkins, *Chief Engineer, Baush Machine Tool Company.*

PRODUCT DESIGNERS are in a quiet room apart

Development Procedure for Machine Tools

By E. C. BULLARD

Research and Development Engineer, The Bullard Company

PROBABLY the easiest and yet the most fatal policy for any machine builder is that policy whereby very little, if any, development work is carried on. Recognizing this, the Bullard Company has consistently and persistently maintained a forward looking policy of new machine development. Since the founding of the company in 1880, there has been a constant development in new types of boring and turning tools, and a gradual but constant refinement in the operating details of the standard machines.

From the first Bullard designed lathe, capable of only meagre production possibilities as compared to present day standards, to the present line of Vertical Turret Lathes and Mult-Au-Matics, capable of production possibilities far beyond the imaginings of only twenty years ago, the constant aim has been to create a machine possible of accomplishing a given maximum task in the shortest possible time with the smallest cost to the customer, and naturally, a commensurate reward in the way of profit to the builder. The product development policy has been that something new must be in progress at all times in order to be progressive and to meet the advancing requirements of the markets.

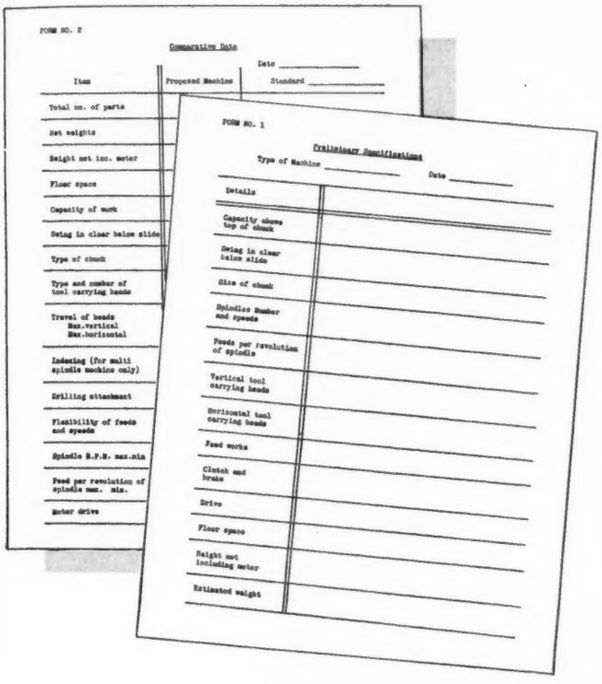
With the above ideal as a starting point, it is necessary first to find the task or type of work which we wish to accomplish, and as this has been and is, for us, in general boring and turning work, we have established the class. But in every class there are many problems, such as large and small work, large work in small quantities, as well as small work in large quantities.

Following this line of thought and from information and statistics furnished by the sales engineers and from personal contact of our development engineers with industry, we can then determine the type of machine tool, its qualifications and capabilities, that we wish to build and offer to the industries—a machine within our class but also intended for specific manufacturing conditions or operations and for which a market has been determined.

WHEN a new type of machine is determined upon, the next step is a general sectional layout showing the conception of the designer of how this type should function. This layout is made in pencil on tracing cloth. Along with the layout, complete specifications are drawn up showing in detail the capacities, speeds, feeds, and other characteristics that may be required. In order that we may have a direct comparison with machines of the same general type, a sheet of "comparative data" is made up showing comparisons with one or more of the standard machines of the company. This aids in our determination as to relative costs, functions, and capabilities. It cannot be emphasized too strongly the absolute necessity of a thorough study of the preliminary specifications of a new product before proceeding with the actual design, as much time and effort can be uselessly applied if serious changes are found to be necessary after design work has been partially com-

pleted. This comparison with standard machines also aids in visualizing in advance the possibilities of employing standard units or mechanisms used on other machines or variations therefrom.

When this has been accomplished, it is the signal for a "Round Table" conference at which the president, the chief engineer, the development engineer, the sales manager, the sales engineers, the factory manager, and representatives from various shop departments are in attendance. All phases of the proposed machine are



PRELIMINARY SPECIFICATIONS are drawn up on mimeographed form sheets

then discussed and comments as to cost and methods of manufacture, methods of assembly, total cost of machine, and its application in industry, are solicited with the idea of reducing not only the cost of the machine itself but of the time of actual development, designing, and placing.

The first step after the conference is to bring the original specifications up-to-date and to make any changes necessary in the general sectional layout, as brought out from the discussion. One engineer, who is known as a "calculation engineer," is then assigned the task of compiling calculations covering stresses and strengths of all shafts, gears, and sections. While this is being done other engineers start the actual layout and design work. In this design work the experience with other machines of the company is, of course, of great value both in planning improved mechanisms or materials and in incorporating units from standard machines.

The calculation engineer works directly with the designing engineers, and any changes made by them that in any way may affect the strength or tend to increase stresses are checked thoroughly before these changes are incorporated into the final design. The layout work thus progresses rapidly, as the designers can devote their entire time to developing ideas which promote ease of assembly and reduce machining costs instead of having to interrupt their thought trend by intermittent calculations. Also, as the calculations are kept by the engineer in easily referable form and right up to the minute, it is possible to check at any time what design changes and improvements have been made.

Constant supervision by the engineer in charge is considered very essential since he acts as liaison officer between the designers and the shop divisions. Many questions naturally arise as to method of manufacture affecting design, and since development work must take into account the final cost of the product, it is absolutely necessary that the designs finally adopted be capable of ready manufacture. Also, the development engineer is in direct touch with the sales engineers, for they are the men who must eventually sell the product and make it produce to the complete satisfaction of the customer.

In this way the completed design is worked out thoroughly, ever bearing in mind not only strength and proper functioning of the machine elements but also the necessity of ease in assembly, simple machining operations, and the possibility of unit construction which this company has long held as one of the means of building a high grade product at a reasonable cost.

WHEN the design work has been accomplished, detailing, checking, and the making of list of parts is started. Contact between the designers, detailers and checkers is maintained and any changes materially affecting the design are referred to the designers before being definitely adopted. The product designers are in a quiet room apart from the main drafting room. In the latter the checkers occupy one corner of the room, and in addition to checking the drawings they make out the parts list for the new machine. Dimensions and limits for various fits have been standardized as have the proper materials, and heat-treatments, and only under exceptional circumstances is it necessary that the designers be called upon to determine these. It is, of course, essential that the development engineer keep himself fully informed as to new materials and their uses, and constant experimentation is carried on to determine the fitness of new materials and new processes. Only in this way can progress be made and the products kept up-to-date.

With the detailing and checking accomplished, the development work has only started, for after blueprints and lists are in the shop it should be the duty of every development engineer to help acquaint the shop men with the new product. From the man who time studies each piece to the man who erects the machine can come

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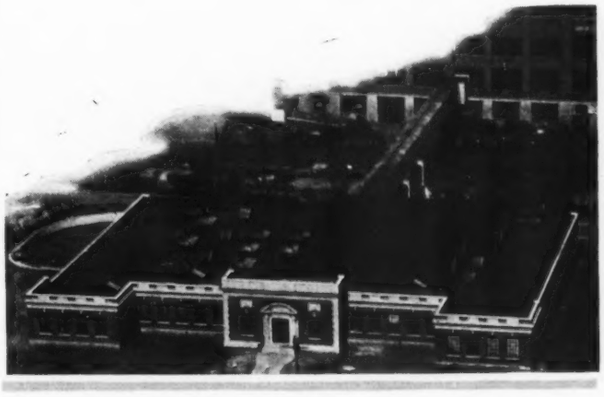
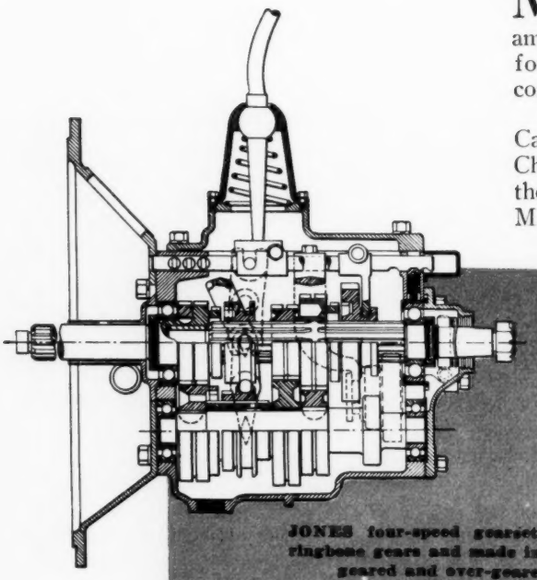


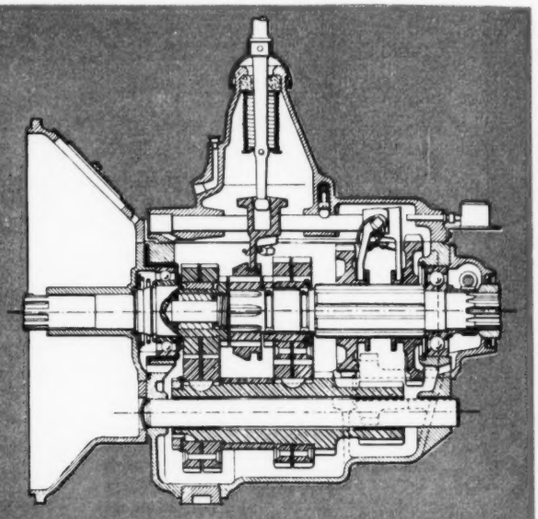
THREE- AND FOUR-SPEED

MANY American passenger car gearsets have undergone radical changes in recent years. Internal and herringbone gears are among the innovations intended to promote quiet operation. Current four-speed and other recent designs are reproduced here along with conventional three-speed designs for comparative study.

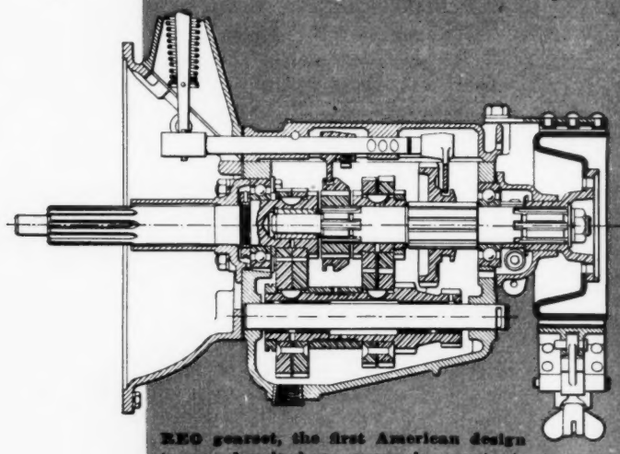
A paper entitled "Comment and Criticism of American Passenger Car Gearsets," and including these drawings, prepared by Herbert Chase, Associate Editor of *Product Engineering,* for presentation at the Summer Meeting of the Society of Automotive Engineers, May 26, 1930, gives a full discussion of these designs.



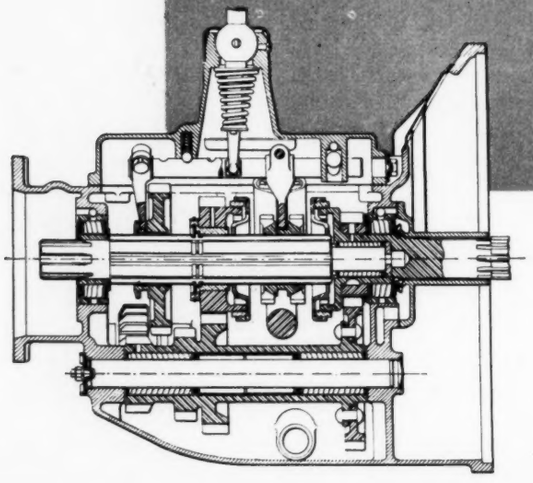
JONES four-speed gearset, using herringbone gears and made in both under-geared and over-geared types



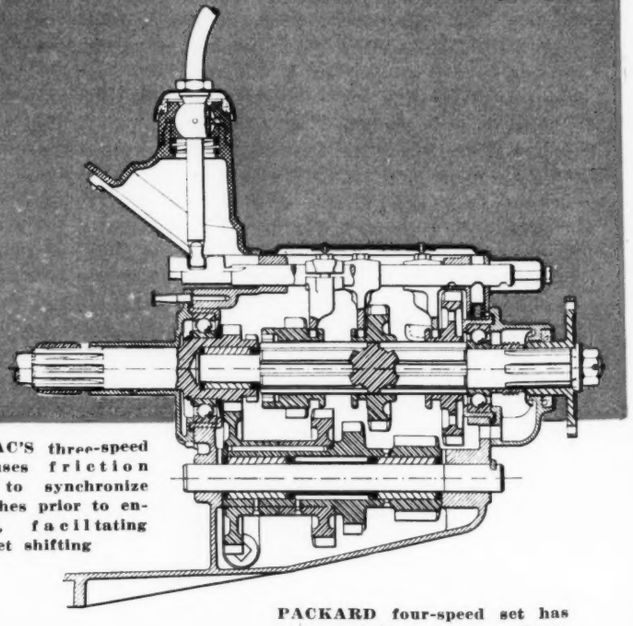
PIERCE-ARROW uses herringbone gears for quietness in constant-mesh and third speed trains of this four-speed gearset



REO gearset, the first American design to use herringbone gears in constant-mesh and second-speed trains

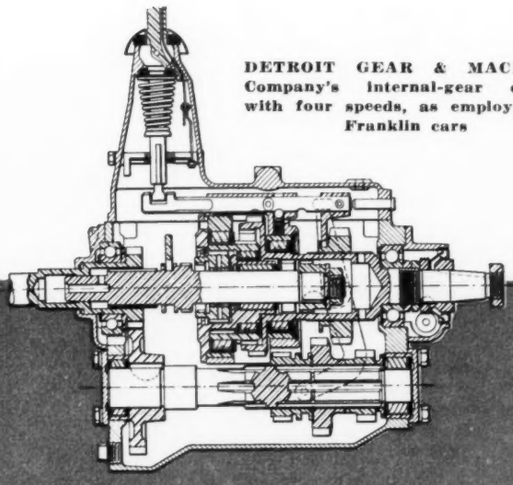


CADILLAC'S three-speed design uses friction clutches to synchronize dog clutches prior to engagement, facilitating quiet shifting

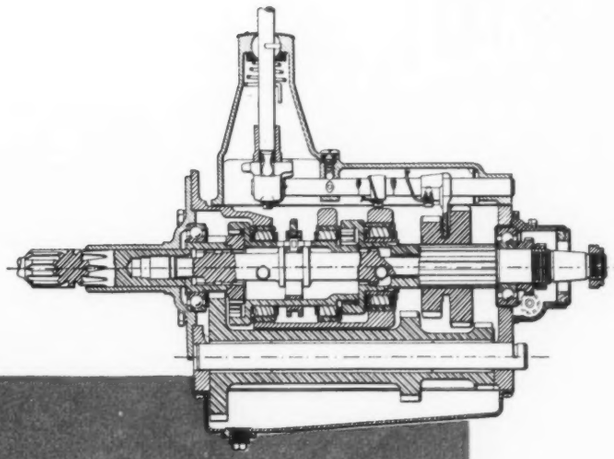


PACKARD four-speed set has only straight spur gears. Teeth are ground to minimize noise in operation

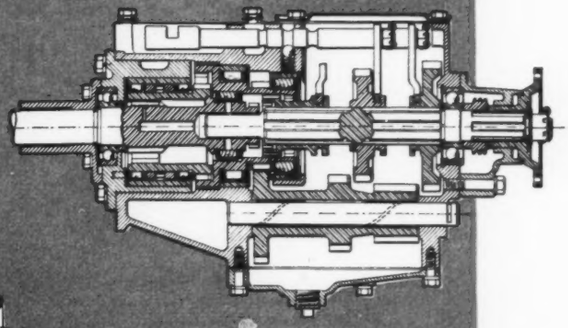
GEARSETS



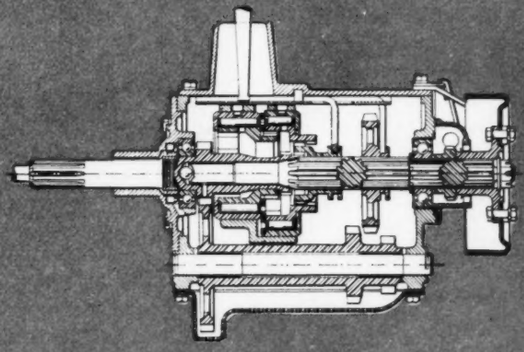
DETROIT GEAR & MACHINE Company's internal-gear design with four speeds, as employed on Franklin cars



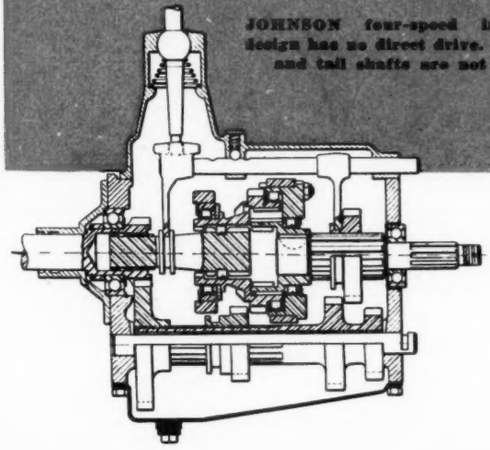
WARNER-GEAR design with internal-external gears, as used on one Marmon model and several other cars



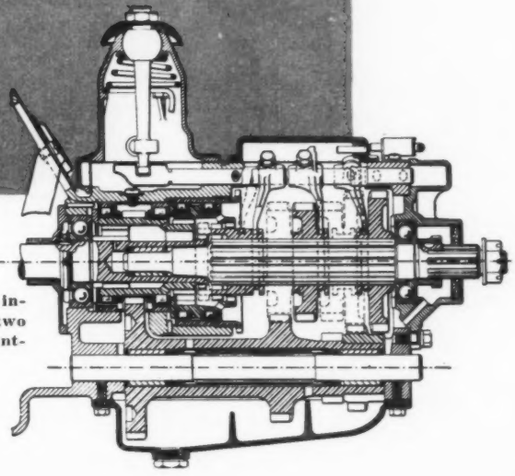
DURANT'S latest four-speed design, employing internal gears and three reductions in the constant-mesh train



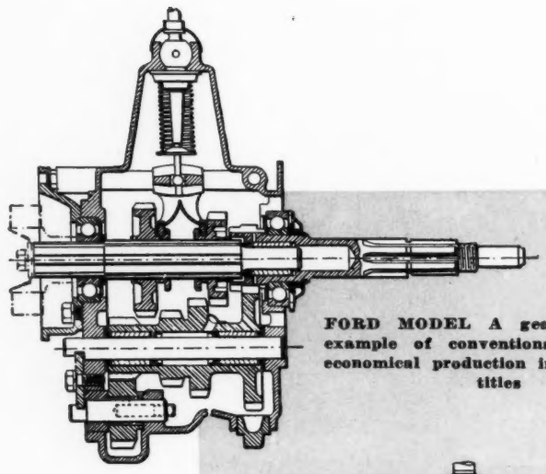
MORSE gearset, one of four designs of the Morse Chain Company using internal gears for next-to-top speed



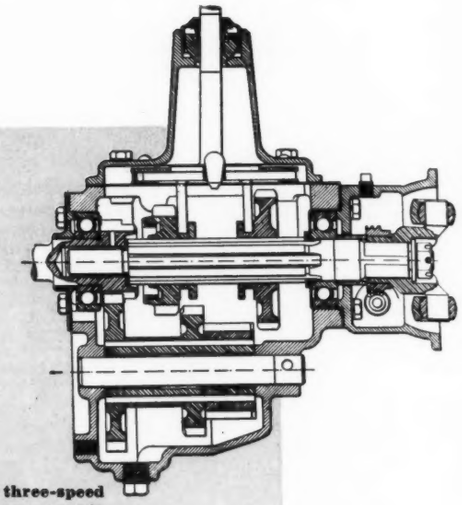
JOHNSON four-speed internal-gear design has no direct drive. The clutch and tail shafts are not co-axial



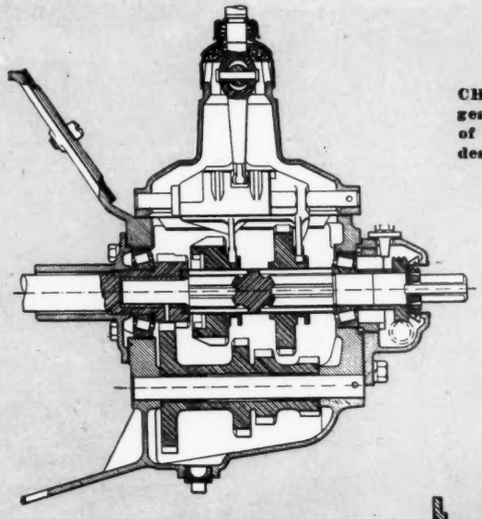
CHRYSLER four-speed internal-gear design has two reductions in the constant-mesh train



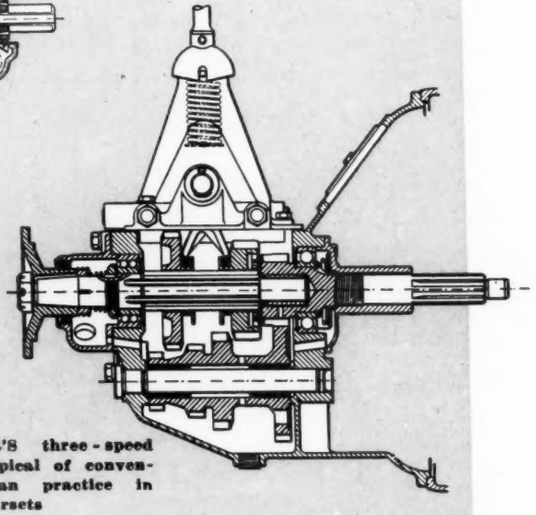
FORD MODEL A gearset, a good example of conventional design for economical production in large quantities



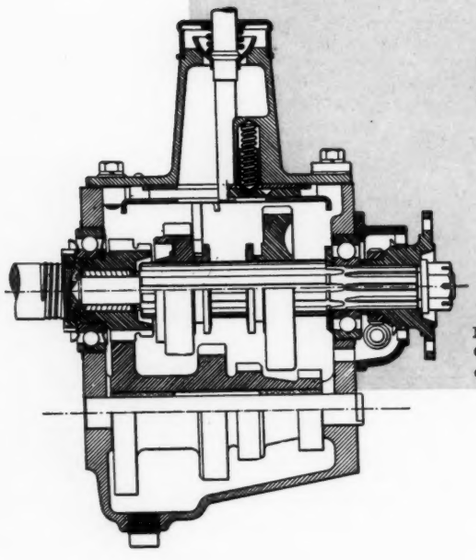
CHEVROLET three-speed gearset, another example of compact conventional design for quantity production



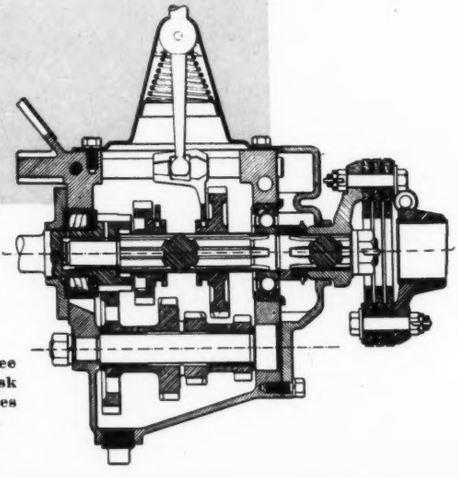
WHIPPET three-speed design, in which taper-roller bearings are fitted on the main shaft



STUDEBAKER'S three-speed designs are typical of conventional American practice in gearsets



MUNCIE gearset, used by Oakland, is similar to sets used on other General Motors' cars



NASH gearset with three speeds. The fabric disk universal joint insulates this set from axle noise

STRESSES
in symmetrical tubes

By GEORGE F. NORDENHOLT
Associate Editor

Method of calculating the bending moments in the walls of rectangular tubes—Concluding article, giving final equations

IN REGARD to analysis of bending moments, the simplest shape of rectagular tube would be one having square corners, such as shown in the accompanying figure. When subjected to internal fluid pressure, bending moments will be set up in the walls of such a tube, tending to change it to a circular shape. In addition to the bending moment stresses, there will be shear and tension.

In a previous article it was shown that in a symmetrical ring such as shown in the figure, the bending moment at the section where the X axis crosses, is:

$$M_o = \frac{pa^2}{2} - \frac{p}{2l}(I_x + I_y) \qquad (1)$$

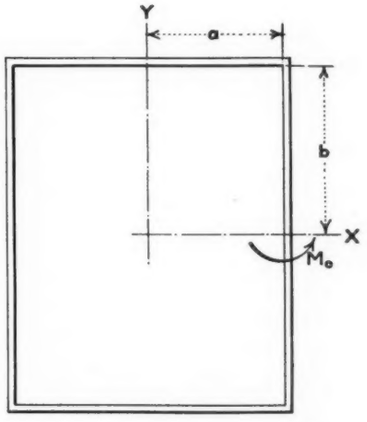
The quantities a and M_o are designated in the figure. The unit internal pressure is p, and I_x and I_y are the moments of inertia of the line about the X and Y axes. The linear length of the quadrant of the symmetrical ring is designated as l.

Referring to the figure, for the side whose dimension is b, we get

$$I_x' = \tfrac{1}{3}b^3$$
$$I_y' = a^2b$$

Similarly for the side a,

$$I_x' = b^2a$$
$$I_y' = \tfrac{1}{3}a^3$$



SQUARE CORNERED rectangular tube subjected to internal pressure of p lb. per square inch

Adding up all of these quantities we get the moments of inertia for the two sides about the X axis and the Y axis, or,

$$I_x + I_y = \tfrac{1}{3}a^3 + a^2b + b^2a + \tfrac{1}{3}b^3$$
$$= \tfrac{1}{3}(a+b)^3$$

Also, $$2l = 2(a+b)$$

Hence
$$M_o = \frac{pa^2}{2} - \frac{p}{2(a+b)}\cdot\frac{(a+b)^3}{3}$$
$$= \frac{pa^2}{2} - \frac{p(a+b)^2}{6} \qquad (2)$$

As set forth in the previous article, the bending moment at any point in the ring is,

$$M = M_o - \frac{pa^2}{2} + \frac{px^2}{2} + \frac{py^2}{2} \qquad (3)$$

The maximum bending moment in this rectangular ring will occur at the corner where $x = a$ and $y = b$. Substituting these values in the above equation:

$$M = M_o + \frac{pb^2}{2}$$

Substituting the value of M_o as given in equation 2,

$$M = \frac{pa^2}{2} - \frac{p(a+b)^2}{6} + \frac{pb^2}{2}$$
$$= \frac{p}{3}(a^2 - ab + b^2)$$

If the tube be square in section then $a = b$, and

$$M = \frac{pb^2}{3}.$$

Taking h as the length of one side of the square tube,

$$b = \frac{h}{2} \text{ or } b^2 = \frac{h^2}{4}, \text{ from which}$$

$$M = \frac{ph^2}{12}$$

This shows that the bending moment in the corners of a square ring or tube subjected to uniform internal pressure is the same as the bending moments at the built-in ends of a fixed beam carrying a uniformly distributed load.

Usually tubes of rectangular cross-section have rounded corners. Such a section is shown in the second figure. The dimensions will be taken as shown in the figure. As before,

$$M_o = \frac{pa^2}{2} - \frac{p}{2l}(I_x + I_y) \qquad (1)$$

The value of I_x can readily be calculated by dividing the quadrant of the ring into its three component parts, namely, the two straight lines and the quadrant of a circle. The moment of inertia of the last about the X axis

is calculated from the equation

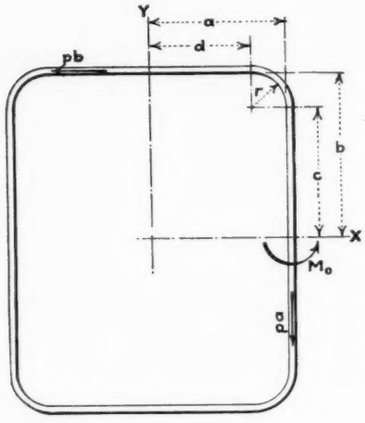
$$I'_x = \int_{b-r}^{b} y^2 ds$$

Here $ds = rd\theta$

$$y = (b - r) + r \sin \theta$$

Following through the integration, and adding the moments of inertia of the two lines and the quadrant of the circle, we get

$$I_x = \tfrac{1}{3}(b-r)^3 + \frac{\pi r}{2}(b-r)^2 + 2r^2(b-r) + \frac{\pi r^3}{4} + b^2(a-r).$$



RECTANGULAR tube with rounded corners, subjected to *p* lb. per sq.in. internal pressure

Similarly,

$$I_y = \tfrac{1}{3}(a-r)^3 + \frac{\pi y}{2}(a-r)^2 + 2r^2(a-r) + \frac{\pi y^3}{4} + a^2(b-r)$$

The value for I_x and I_y can be calculated separately, using the numerical values of a, b and r for the specific problem. The value of M_o can then be readily calculated by substitution in equation 1. Having obtained M_o the value of M at any point in the ring can be obtained from equation 3, using corresponding values of x and y. In this way the bending moment diagram for the ring section can be plotted.

By differentiating the equation for the bending moment and putting it equal to zero, it is shown that the point of maximum bending moment is where

$$y = \frac{cr}{\sqrt{c^2 + d^2}} + c,$$

the quantities being as designated in the figure. The corresponding value of x can readily be calculated. The maximum bending moment and its location can thus be obtained directly.

In addition to the bending moments, the walls of the tube are subjected to tensile and shearing stresses. The tensile force acting in the vertical leg will be equal to pa, and in the horizontal leg the force pb is acting. At any radial section in the rounded corner, whose co-ordinates are x, y, the forces px and py will act vertically and horizontally, respectively. The components of these forces taken normal and parallel to the radial section will give the tensile and shearing forces acting on that section.

When calculating the bending moment stresses at the corners, this section of the ring must be treated as a curved beam. The maximum combined stresses required to resist bending, shear, and tension is then calculated in the usual manner.

Pressed Fits on Power Shafts

By Paul B. Swinton

FRANK BARBER, chief engineer, was in a jovial mood when I entered his office. I had read in the trade papers the announcement that his new press was on the market, and attributed his good humor to that fact. Naturally, our conversation soon got on the subject of his new machine.

"What new design features are there?" I asked.

"Lots of them," answered Barber. "The machine is of entirely new design from bed plate to paint. But what strikes me as being the outstanding design wrinkle on the whole machine is the hub of the main gear."

"That seems to me to be rather an insignificant detail to classify as exceptional design."

"I thought so too," said Barber, with a laugh, "but wait until I tell you what trouble we had. In the first place, we had to press the gear on the shaft. That was easy enough to do, but when we tested the machine the shaft broke—a cup facture at the section where the shaft entered the bore of the gear.

"The first thought was to make a new shaft and heat-treat it. This we did, but again the shaft broke with the same characteristic fracture. The next shaft was made of chrome-nickel steel, but the result was the same.

"Between you and me, I was worried. Calculations did not help any. And worst of all, we could not change the size of the shaft without rebuilding almost the entire machine. We had to use a pressed fit because there was no way to key it. And then when things looked worst one of our research men solved the whole problem.

"He reasoned it out this way. The pressure of the press fit stressed that portion of the shaft which was gripped in the hub. But these stresses fell off very rapidly to zero in the shaft outside the hub. On the other hand, the twisting moment stresses in the shaft existed fully up to the point where the shaft entered the hub, and then rapidly reduced to zero. Where the shaft entered the hub you had the effect of the sum of these two stresses. His idea was to reduce the press fit stresses in the shaft for a short distance into the hub at the section where the shaft entered the hub, and yet have a tight enough fit at this point between the shaft and hub so that the hub could take up some of the twist on the shaft as soon as the latter entered the hub. In this way the maximum total stress would be greatly reduced.

"The idea sounded good, and his reasoning perfect, but how was this delicate gradation of pressure to be accomplished? The research man pointed out that if we were to cut a concentric groove in the face of the gear hub on the crank side, the trick would be accomplished. The groove was to be about a half-inch deep and about the same distance from the shaft. We did it, and the severest kind of test did not break the shaft. So now I'm smiling."

The groove virtually had the same effect as turning down the hub diameter, thereby decreasing the wall stiffness at that section and thus relieving the press-fit pressure on the shaft. Before reaching the section of the shaft where it was subjected to the full press-fit pressure, the twisting moment stresses had been materially reduced, resulting in a corresponding decrease in the total stress in the shaft.

Possibilities of Molded Products

CLOCK CASES are examples of parts where difficult metal-drawing has been effectively replaced by resinoid molding. Mottling and color mixing are easily produced

Illustrations from General Plastics, Inc., and the Bakelite Corporation

By GEORGE S. BRADY

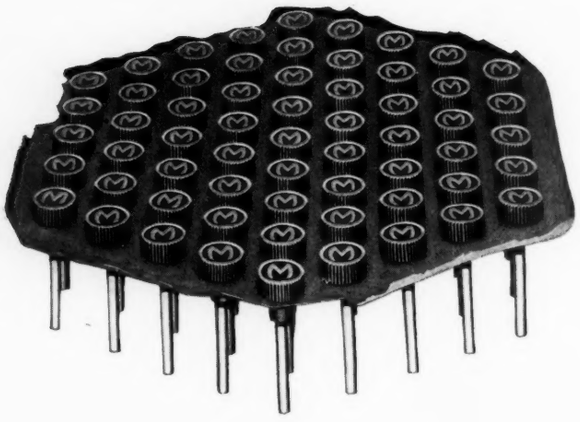
NOT SINCE Bessemer made it possible to produce steel at a very low price has any material so quickly and so effectively found a place in industry as the resinoid molding compounds, particularly what are known as the phenolic compounds. These materials have replaced metals, wood, and ceramics in an increasing variety of products because of their ease of molding into most intricate shapes, their strength, durability, lightness, acid and corrosion resistance, dielectric strength; and because they can be readily produced in attractive finishes and colors that would be difficult or impossible in any other material.

FOUR PARTS of this electric razor are made by molding. The handle and cap are in two colors and have a high finish

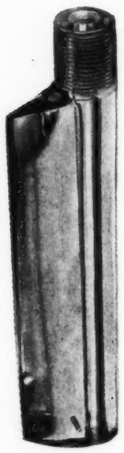
The finish in molded plastics is an integral part of the material, and not a surface coating, so that the article retains its original luster without refinishing, and cannot corrode or lose color. Some of the commercial products in which colored plastics have been used effectively are: clock cases, radiator caps, switch plates, radio parts, door knobs, bottle and jar caps, containers, lamp stands, novelties, ignition parts, handles, steering wheels, meter cases, trays, furniture parts, stove handles. These articles are made in plain colors or in mottled or striated designs. All arrangement of the color is done in the raw product, however, so that when the part comes from the mold it is completely finished and requires no further coloring or burnishing.

The use of color, finish, and ornament in molded materials is preeminently a merchandising matter, but it is one that can be carried on successfully only with the active cooperation of the designer. The sales department may specify what color or finish it desires in a part, but it falls upon the designer to ascertain how this finish may be obtained most effectively and economically. The companies producing the phenolic molding compounds offer a great variety of different grades of these materials varying in physical properties, capacity for taking color, plasticity, heat resistance, dielectric strength, and other factors. The cost of certain grades is about three times that of others. It must be remembered that these phenolic compounds constitute only one series, and that while they are the most widely employed for most commercial parts, other compounds are sometimes more suitable, either because of cost or physical properties, for specific purposes. For example, the translucent pastel shades are not obtainable in the normal phenol resin, and may be obtained more economically in the urea, phthalic-anhydride, and certain other compounds. On the other hand these latter resins present other problems in molding. A general knowledge of the properties of these different resins is therefore a requisite of the designer's equipment.

FINISH, expressed in luster and ornamentation, is essentially a function of the molding die. All of the synthetic-resin compounds have the property of molding under heat and pressure to delicate and exact shapes, very thin and intricate sections being possible. The cost of such molded parts, not considering the weight of the piece, is a function of the cost of the necessary die. In this respect the economics of molding parts is simi-



QUANTITY MOLDING of small parts in multiple molds requires only breaking off of the connecting fin to complete the part. The part shown is molded to a metal pin insert



AIRPLANE gasoline gage molded of amber-colored but transparent phenol resinoid. The prism shape magnifies the indicator column

THIS SEWING BOX indicates the possibilities in molding large and intricate parts with powder compounds. It is molded in three pieces only. Molding with laminated materials would require cutting out and building up the sections before pressing. The box is amply strong for the intended use

lar to that of pressed-metal parts. Where expensive dies are required to produce intricate parts, the quantities of parts required must be large enough to bring down the per-piece cost to a reasonable basis. For small parts, however, this factor has been greatly simplified by the fact that molding can be done on a large number of parts simultaneously, and the cost of the dies is reduced by hobbing the multiple dies with hard steel hobs.

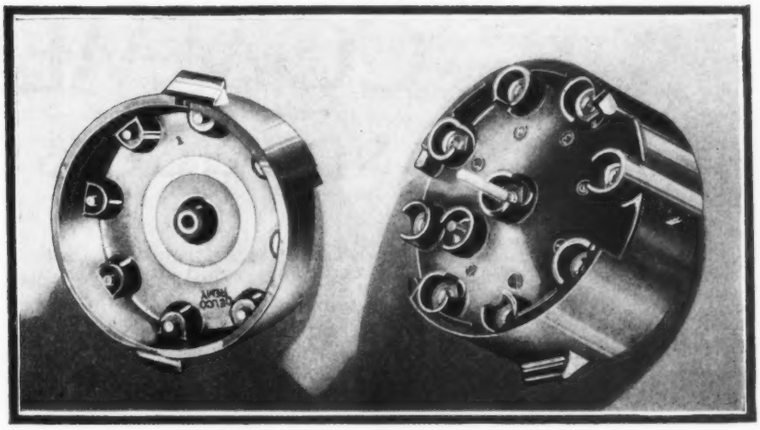
In the case of casting hot metals, as in die casting, intricate designs and ornament on the molds deteriorate rapidly, the fine edges burning off from continued contact with the molten metal. But in molding with resins this factor is non-existant, and consequently greater quantities from the dies and greater accuracy throughout the life of the mold can be expected in molding than in die casting. Likewise, either depressed or raised ornament or lettering may be employed indiscriminately. The high polish of the molded article is obtained directly from the fine polish of the mold.

Color in the molded part is ordinarily obtained by the use of dye or pigment with the original semi-cured molding resinoid. The production of the compounds themselves are complex chemical processes, and are not usually associated with the molding, molders purchasing the raw molding material ready for the presses and mixed with the desired filler.

The great bulk of all ordinary molded mechanical and electrical parts is made from the phenol resins. This is mainly because of the ease of molding, and of the fact that because they are "set" at a relatively high temperature and pressure (350 deg. F. at 2,000 lb. per sq.in.), they

HEAT RESISTANCE makes the phenol compounds adaptable for stove, range, and cooking appliance handles and ornamental parts. All colors are employed

are resistant to any heat that might ordinarily be applied. The colors obtainable with these resins are, moreover, entirely satisfactory for mechanical parts. In fact, most of these products are generally produced in brown, green, or black. The mechanical strength of the molded parts is high, 8,000 lb. per sq.in. tensile, and 36,000 lb. per sq.in. compression, but varies according to the amount and type of filler used with the resinoid. This "filler," or reinforcing material, which in most cases consists of wood flour, is employed to make the molding material more readily workable and to increase mechanical strength. When light colors are employed sufficient pigment must be added to cover the yellowish tint of the filler and the amber tint of the resin. For this reason the excess of pigment in obtaining white or pastel shades reduces the mechanical strength of the molded part. Where these colors are desired, as in fountain-pens and



CADILLAC timing part molded in a phenol compound. It is an excellent example of very accurate molding of an intricate part with numerous metal inserts accurately spaced

ornamental objects, casein or other molding materials are employed without filler. Although these latter materials have the advantage of being machineable, they are not frequently used for mechanical parts because of their softness and low mechanical strength.

In changing designs from metal to molding materials, or in developing design to include molded parts in the product, the metal-product designer without previous molding experience must consider a number of points in addition to the choosing of the class of resin and the color and finish. Hot molding, as required for the phenol resins, is a specialized process, requiring special presses and equipment and skillful design and production of dies. If the quantities of molded parts to be required are not apt to be very large, it will not be economical to install a molding department. On the other hand, even though the requirements are considerable, it will often be found advantageous to have the parts made by custom molders who specialize in this work. The work of die making and production molding is so distinct from the ordinary run of other jobs in a metal-working plant that it cannot be handled properly unless the plant can afford to acquire competent molding supervision as well as skilled workmen and special equipment.

TELEPHONE parts are now being made largely in phenol resinoid compounds. The dielectric strength is high, and they retain their high luster and clean appearance in constant use

The parts to be molded should also be designed with molding production in mind. All of the custom molders furnish engineering service to aid prospective customers in designing the product for most economical production. The makers of the molding materials also have service departments for this purpose and are in the most advantageous position to provide data on color and finish possibilities. It should be remembered in this respect that molded parts are not polished or finished after molding, but that they take the finish of the die so that any high polish or art work required must be a part of the die. This fact must also be considered by any plant thinking of molding its own product parts. The production of the molds requires a high class of tool work, and this constitutes one of the largest items of expense. Expensive molds are warranted, however, where large production will bring down the unit cost of the part.

CEILING LAMP fixture with all outside parts molded. For this class of product the molding compounds are replacing metal in increased quantities

The field of application of the phenol resin molding materials is practically unlimited and the list is constantly increasing. Frames for such machines as typewriters and adding machines are prophesied for the near future. The wooden parts of kitchen utensils are being almost entirely replaced by molded parts in color. The success of molded parts for all kinds of novelties has pointed the way to the use of the material for industrial parts where odd shapes are required in a material that has durability, appearance, and resistance to acids, oils, and moisture.

For data on laminated molding the reader should refer to the article Laminated Molding Materials, in *Product Engineering*, January, 1930.

COMMENT AND SUGGESTION

Checking Drawings

By C. G. Williams
Chief Engineer,
Green Bay Barker Machine & Tool Works

ACCORDING to the method of checking drawings as presented by Mr. Matthews in the February number of *Product Engineering,* the checker puts a letter of the alphabet at every place or dimension where there is an error or question as to correctness. The letters are the keys to a tabulated sheet of corrections, made and retained by the checker. The drawing or print is returned to the detailer who "is compelled to recheck his work and correct it, whereas, had the correct figures been placed upon the blueprint, he would probably have copied them without bothering his head. . . . "

While working in a drafting room operating under that same system, I had the opportunity to observe how it works out. There is no question in my mind but that such a system greatly slows down the work of the drafting room. Furthermore, I cannot see that it has any offsetting advantages.

Any detailer who is so disinterested in his work that he will not question the corrections made by the checker, is not worthy of his position. Operating under the usual checking system, such a man would soon lose his job. It is true that the system advocated by Mr. Matthews compels the detailer to "figure out" his errors, which he would probably do anyhow, and in that way makes a good training school. On the other hand, the drafting room should not be considered as a grade school wherein the inmates must be compelled to rectify their mistakes thoughtfully.

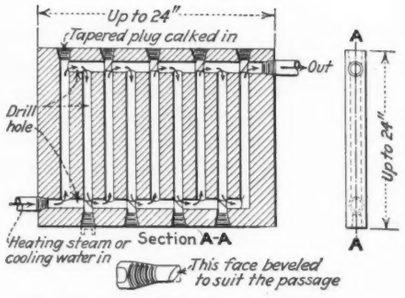
■

Steel Molding Press Platens

By T. M. Namiky
Tokyo, Japan

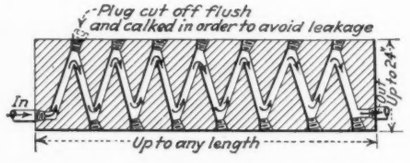
MOLDING PRESSES, which are coming into increasing use in the making of all kinds of parts from the synthetic resins, offer some interesting problems in design. One of these is the heating and cooling platen. This platen, or plate, is an essential part of the machine for compound molding, and it is subjected to repeated heating and cooling with steam and cold water.

The ordinary plate for the purpose is of cast iron made up as in the illustration. It is sometimes made by casting in cores or steel pipes to form the required passages. But making a perfect cast-iron plate that is nonleakable, and has good conductivity, that is, quick heating and cooling with a minimum of heat loss, is very difficult indeed. After bitter experiences in making plates of cast iron we finally adopted mild steel.



Ordinary rectangular plate offering no difficulty up to 24 in. in length. The plug ends are made to guide the steam and water

Both of the plates shown are of mild steel. The first design is for short plates, and the second for long ones. The plates were designed so that they could be drilled in the ordinary machine shop without special equipment. In both cases the taper plugs are screwed in tightly with a wrench, and then the ends cut off and the whole sealed by calking. Welding can be used for the seal. These make very satisfactory platens.



Platen design where lengths exceed 24 in. The plug ends are cut off and the edges sealed either by calking or welding

■

STOP . . . LOOK . . . LISTEN . . .

. . . BEER BUGS VS. MACHINES . . .

REPORTS from a recent meeting of the American Chemical Society state that a newly discovered beer bug, *basillus delbrueckia,* obtained from brewer's malt, is destined to replace powerful crushing machines in extracting oil from flinty dried cocoanut. This interesting discovery is described by Dr. John Woods Beckman, as "opening up a new industry that will substitute bacteria for workmen and machines to make vegetable oils and fats at low cost."

Apparently neither the engineering societies nor the trade unions are to be consulted. Our guess is that they couldn't change the situation much even if they were asked.

But why worry? If the market falls off a little on heavy crushing rolls, it's likely to pick up a few points on distillerata—if that's the correct term for tanks or incubators or whatever they use for propagating bugs and making them feel at home. After all they can't do without the engineer.

. . . GOOD LOOKERS NEEDED . . .

"MAKE 'EM easier to look at, if you want to boost sales," is, in effect, one of the pieces of good advice given by W. B. Stout, president of the Stout Air Services, Inc., in a recent talk to automotive engineers on what the public wants in airplanes. Much the same might be said of scores of other products. There is no use denying that smart, up-to-the-minute appearance counts heavily today, even in engineering products that heretofore have been considered only upon a utilitarian basis.

The American public is learning rapidly to appreciate and look for better appearance in the things it buys. Engineers who are not aware of this fact and are not seek-

Design Trends in Aviation

AVIATION design trends are well expressed in a survey made by *Aviation,* in which outstanding engineers in the industry expressed their views on what is to be expected in the immediate future. The chief points in brief are:

Cantilever type of plane
Supercharged, over-compressed engines
Automatically-adjustable pitch propellers
Devices to reduce landing speeds
Oleo-pneumatic shock absorbers
Further developments in light alloys
More effective controls
Floating aileron
Abandonment of small light-type plane
Safety devices
Higher cruising speeds
Predominance of air-cooled radial engines
Diesel engines in larger sizes of planes
Closer government regulation.

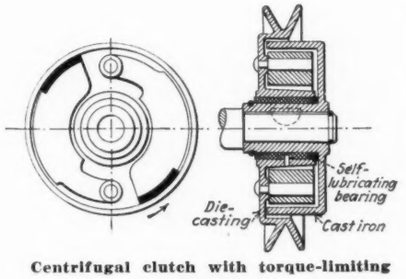
■

Centrifugal Clutch Design

GEORGE W. DUNHAM
Consulting Engineer

IN ELECTRICALLY-DRIVEN household clothes washers that dry by centrifugal force, the starting load, when drying, is of considerable proportions, and means usually are necessary to apply the load gradually so that the starting winding in the motor will cut out as quickly as possible. In one such machine that came to my attention a centrifugal clutch was used for this purpose. It was necessary that it be very compact and sturdy, and that it operate quietly and within a comparatively narrow range. Variation of temperature and humidity had to be taken into consideration, but eventually an asbestos composition was found which would operate quietly and with as nearly constant a coefficient of friction as could be expected.

This combination seemed to be everything that could be desired, but



Centrifugal clutch with torque-limiting feature

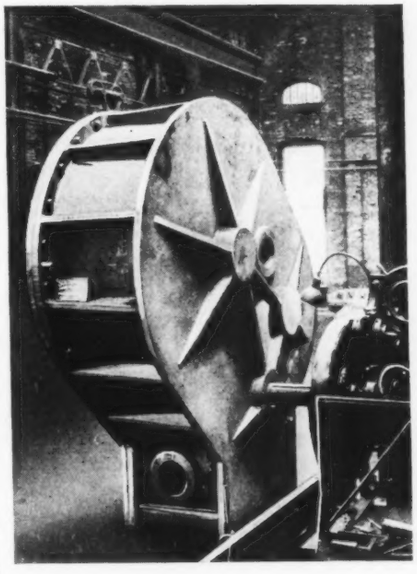
when it was put into use, it was found that the load which it carried varied to such an extent that some change had to be made. It then was decided to attempt to "weigh" the torque automatically in such a manner that a pre-determined load could be carried on the driving surfaces. This finally resulted in the clutch shown in the accompanying cut. This clutch has two crescent-shaped weights, each pivoted at one end on pins at diametrically opposite points on the die-cast driving disk, which is driven by V-belt from the motor. The weights revolve with the disk inside of the outer driven drum. The friction material is secured with rivets to each weight at the end opposite to the pivot pin, as shown, and the clutch revolves in such direction that the drag tends to force the weights in toward the center. This establishes a condition of balance between the centrifugal force acting on the weights and the component tending to reduce the pressure. As a result, the effect of the variation in the coefficient of friction was reduced by something over 50 per cent, or well within satisfactory limits.

■

Large Gear Case Designed for Arc Welding

BY A. F. DAVIS
Vice-President, Lincoln Electric Company

STRENGTH and rigidity are not the only physical qualities to be had of welded steel construction when applied to machine designs. In the large gear case shown, the case had to be



designed with three definite characteristics in view. It must completely encase the gears, support the shaft bearings, and provide facilities for an

. . . FORGED . . .

FORGING today is not confined to that done on paper, or even to that done with steel—not by a jugful. Brasses and bronzes are forged and die-pressed hot into an endless variety of shapes. They include alloys containing, besides copper and zinc, aluminum, lead, tin, manganese, nickel, silicon, and other elements. Strength equal to that of mild steel, and corrosion-resisting qualities comparable to those of high-chromium steels are readily obtainable in such forgings. Much the same can be said of aluminum alloys, and Monel metal also is forged successfully.

•

. . . AD INFINITUM . . .

NO ONE apparently has ever made an attempt to classify and standardize the phenolic molding materials. It is rather bewildering to contemplate the possibilities in variety, considering the claims of the various makers multiplied by the combinations that can be obtained by different mixtures. Some enterprising maker, or combination of makers, ought to classify the most adaptable of these resins and furnish the designer a list of uses and treatments for each in the same manner as do the steel producers.

•

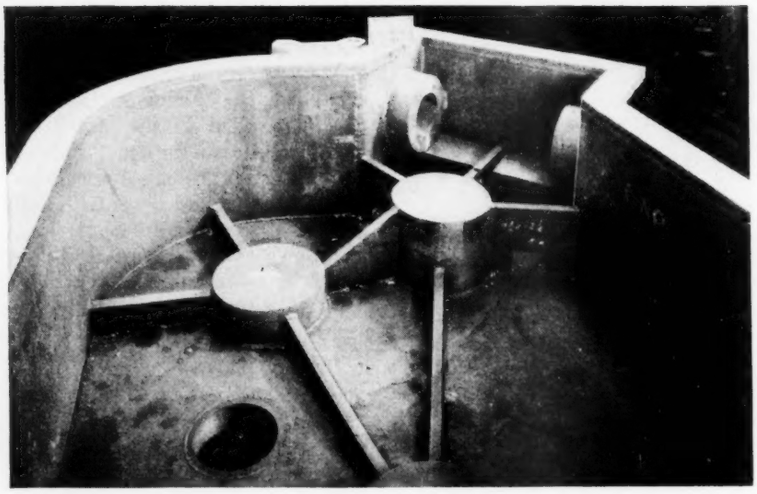
. . . NEW AIR IN OLD CARS . . .

SOON every day will be a May day when riding on the railroad. There are rumors to the effect that one of the leading railroads has several experimental cars equipped with ventilating and air-conditioning apparatus, and the prospects are that it will shortly have its diners so equipped. It is also understood that the Pullman Company in co-operation with manufacturers of ventilating and air-conditioning apparatus is making a study of the possibilities of equipping its sleeping cars with such apparatus. All who travel on a sleeper with hail this with joy!

•

. . . CHROMIUM PLATES . . .

REPORTS from Europe tell about better results obtained with chromium as a plating metal by increasing the depth of coating of nickel or copper under the chromium rather than increasing the coat of chromium. The Germans claim that a coat of 0.004 in. of chromium is necessary to protect steel from oxidation, but that when a heavy undercoat of nickel or copper is applied, only 0.00008 in. of chromium is required. According to the *Brass World* it is no more expensive to plate heavily on undercoating than to plate directly a heavy coat of chromium. If chromium plated parts are not giving the service intended by the designer, somebody might well look into the plating room.



STANDARD PLATE and rounds are utilized in this welded gear case

oil bath, in which the gears run, without permitting leakage.

It would have been possible to construct this case of cast iron, but in order to prevent seepage, and because of molding and casting requirements, the resultant product would have been extremely large and heavy. Another disadvantage of cast construction would have been the time required for making the pattern drawings and patterns, and casting the case. The cost of cast construction would also have been high.

This gear case of welded construction is 10 ft. wide, 10 ft. high, 3 ft. deep, and weighs 32,000 lb. It was designed and constructed by the Southwark Foundry and Machine Company using a standard Lincoln welder to supply the current.

The details of construction of this case are shown by the inside view, in which one cover plate is removed. The cover plates are made of 1½-in. steel plate. The bosses and pads are steel forgings, arc welded into place.

■

Tools Slides Fed by a Toggle

By H. R. LeGrand

TOGGLE MOTIONS are characterized by the great forces that can be obtained by their use, but they become of greater interest when combined with gearing to obtain accuracy of movement as well as force. Such an application was made by the Le Blond Machine Tool Company to feed the tools of its automatic crankshaft lathe. This machine was designed to cut simultaneously on the opposite sides of the crankshaft to prevent its deflection and also effect economies in cutting time. The accompanying illustration shows that a very simple design was worked out.

From a hydraulic cylinder in the base of the lathe, motion is transmitted through a rack on the piston rod to a gear sector on the toggle, and finally to gear sectors which, on opposites sides, mate with racks on the tool slides. These tool bars move at exactly the same rate and exert the same force, but in opposite directions.

Another feature of this toggle arrangement is the automatically-decreasing rate of infeed of the tools as they approach the bottom of the cut. As it is necessary to have a dwell on a forming tool in order to reproduce sizes accurately, a positive stop is employed. When the segment arm *C* strikes this stop, the piston motion is stopped and the pressure in the hydraulic cylinder builds up to a predetermined point, after which a relief valve bypasses the oil into a small dashpot cylinder. This cylinder trips the hydraulic control, thereby reversing the pump and stopping the machine.

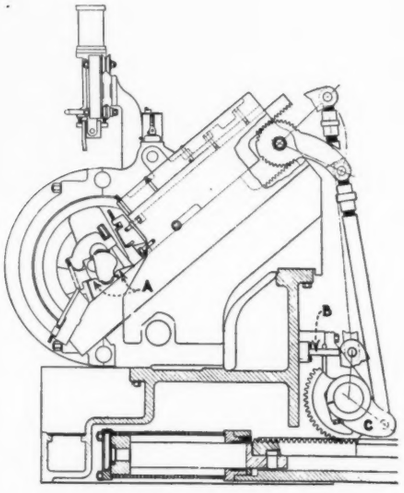


Diagram of tool feeding mechanisms on Le Blond automatic crankshaft lathe

DEVELOPMENT PROCEDURE

(CONTINUED FROM PAGE 221)

many valuable suggestions, and a constant watch is kept for those minor items which in the aggregate can either increase or decrease the final cost. Time study men, in fact, follow the first machine through every operation, not merely to obtain data on the cost, but also to record any difficulties experienced.

When the individual pieces are machined completely, they arrive at the experimental room where each assembly or unit is assembled and given a thorough test. This is the primary "proving ground," and from this room the development engineer learns much: Does it assemble easily? Does it function properly? and last but not least, Does it "look" right? A piece of machinery may assemble and function "beautifully," but may be almost ruined because it does not "look" right. It may be plenty strong enough, yet adding just a trifle of metal here, a little there, and the massive flowing lines stand out as a challenge to the operator to do his best. The chief of the experimental department also formally writes out his recommendations on any proposed alterations or additions as they occur to him or his staff during the trial.

Finally, the first machine comes to the erecting floor. As the parts and units begin to flow to this spot and become an integral part of this new creation, the engineers again have the chance to check themselves. This creation grows, and finally power is applied. But it is only a "youngster" yet, and must be put through its paces before it can be announced as a product of the company. Tests of great severity for efficiency, pulling power, rigidity, quietness, are all made and at these tests are congregated all of the engineers and executives who are vitally interested. Finally, the last great test comes, a period of actual work in our own plant, and only after many gruelling tests does this new product become one of the line.

Design Problems in WOODWORKING MACHINES

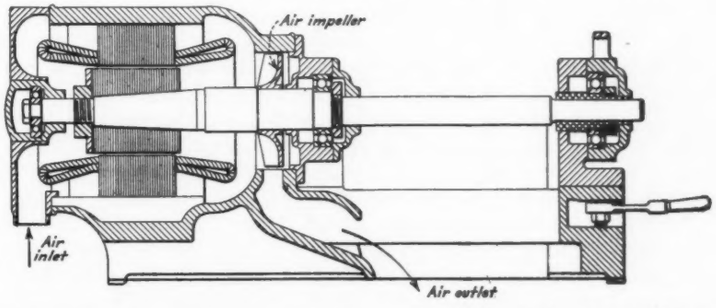
By R. A. WILLIAMS
Yates-American Machine Company

UNTIL recent years, woodworking machinery has been the "orphan" of engineering. Not long ago, in fact, one manufacturer stated that woodworking machines were designed in the pattern shop. At any rate we may say that the product was hardly one of which a designer would be proud. During the last decade, however, woodworking machinery design has passed through a change, and we believe that the average machine built today will compare favorably in both design and execution with the product of more pretentious industries, such as machine tools.

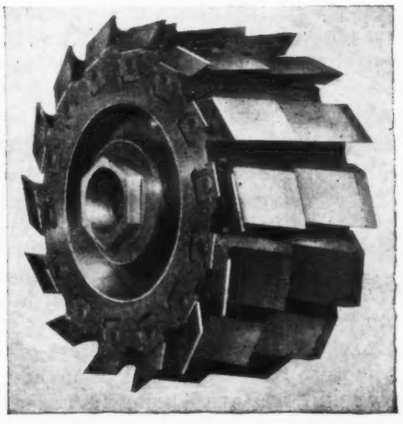
There are certain features of woodworking machinery that make its design unusual. Perhaps the most outstanding is the speed at which the cutter heads operate. With the almost universal adoption of direct a.c. motor drive, these speeds range commonly from 3,600 up to 10,000 r.p.m., the former being the usual direct drive on 60-cycle current, the higher speeds being obtained by the use of higher frequencies supplied from a frequency changer. Since the cutter heads or spindles which are driven at these speeds may weigh up to several hundred pounds, and since during operation they are subjected to the constant pounding of the knives striking the wood, it can readily be seen that dynamic balance, bearing design, and requisite strength offer some nice problems to the designer.

Ball bearings are used almost exclusively for these high-speed cutter heads. This choice is not so much in order to obtain a saving of power as it is for the accuracy obtained, for compactness, and most important of all, for trouble-free operation. Also their use makes possible the employment of built-in motors, now almost universal practice in woodworking machinery.

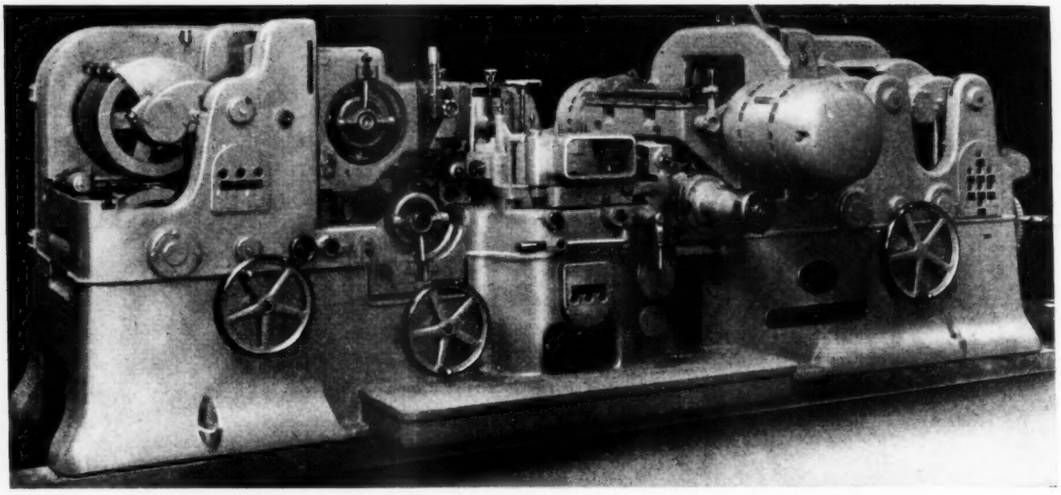
Ordinary commercial ball bearings are not suitable for this type of service as they will not stand the high speeds, and their accuracy is not great enough. Most ball bearing manufacturers now offer for this service a high-precision type bearing which gives very good satisfaction. These bearings are made to about one half the usual commercial tolerances on diameters and eccentricity and with practically no radial looseness. In order to get the full benefit of these high-grade bearings, it is necessary that their mounting be unusually accurate. For instance, the housing which ordinarily supports the outer race with what is termed a "sucking fit," must be finished inside by grinding rather than by boring or reaming. Otherwise, either of the latter operations as ordinarily performed leaves a surface which lacks the density of the ground surface, and under the pounding of operation will allow the bearing to loosen up enough to cause movement in the cutter head and inac-



TYPICAL horizontal molder spindle with built-in motor drive. Speeds from 3,600 to 7,200 r.p.m. are possible. Grease lubrication is employed



MULTIPLE-KNIFE cutter head for operation at speed from 3,600 to 7,200 r.p.m. For adjustment, the inserted teeth have serrated backs and are clamped in place with shoes and headless setscrews



MASSIVE construction is called for in a modern planer and matcher such as this one for finishing siding or ceiling boards at feeds up to 700 ft. per min.

curacy in the work. An indication of the accuracy required of these cutter heads may be obtained from the limits of +0.0003, —0.0000 in. to which the housings and spindles are customarily finished.

In the illustration is shown a characteristic design of horizontal molder spindle design with a built-in motor. Several standard features of woodworking spindle mounting are present in this design. In the first place, the rotor, which is simplicity itself in an induction motor of this type, is mounted directly on the spindle with a taper fit and locknut. Each bearing is carried in what might be termed a cartridge-type housing, the diameter of the middle one being large enough to pass the rotor through the opening in the motor frame. In this way the entire spindle assembly may be pulled out of the motor frame without exposing the bearings, an important consideration as a small chip of wood can ruin a ball bearing. The bearing cartridge at the left slides freely in the housing so as to position itself when the shaft expands.

THE cutters must be readily removable; consequently it is essential that the outboard bearing be easily slid off the shaft. For portability, the pedestal has a handle cast on top, and is held to the frame with a quick-acting clamp. Enclosures are simple, consisting merely of close running clearances made possible by the small tolerances in the bearings themselves. Because the motor frame is totally inclosed, forced ventilation is necessary, gained by a centrifugal impeller mounted on the spindle as shown. This fan draws air through the gap and around the stator core, discharging it through cored passages in the frame.

Speeds above 3,600 r.p.m. are too high for the regular ball thrust bearings, and it is the usual practice, therefore, to carry all end thrust on radial deep groove or angular contact bearings. This is the case even with vertical cutter heads having a fairly heavy thrust load such as the matcher spindle also shown in cross-section.

IN this example the lower bearing carries the weight load of the rotor, axial cutter loads, and a small amount of radial load as a result of unbalance in the rotor and overhung cutter loads.

As in the design of the molder spindle, cartridge mounting is employed for both bearings, and the arrangement is such that rotor and bearings may be withdrawn intact without exposing them to dirt. A matcher spindle must be capable of vertical adjustment while running. This is attained through the medium of a swinging link actuated by a screw and hand-wheel. By means of a fulcrum pin, the link is attached to the lower bearing cartridge, which is free to slide vertically. During movement of the lower cartridge, the upper cartridge is fixed, movement taking place between the outer race of the ball bearing and the shell.

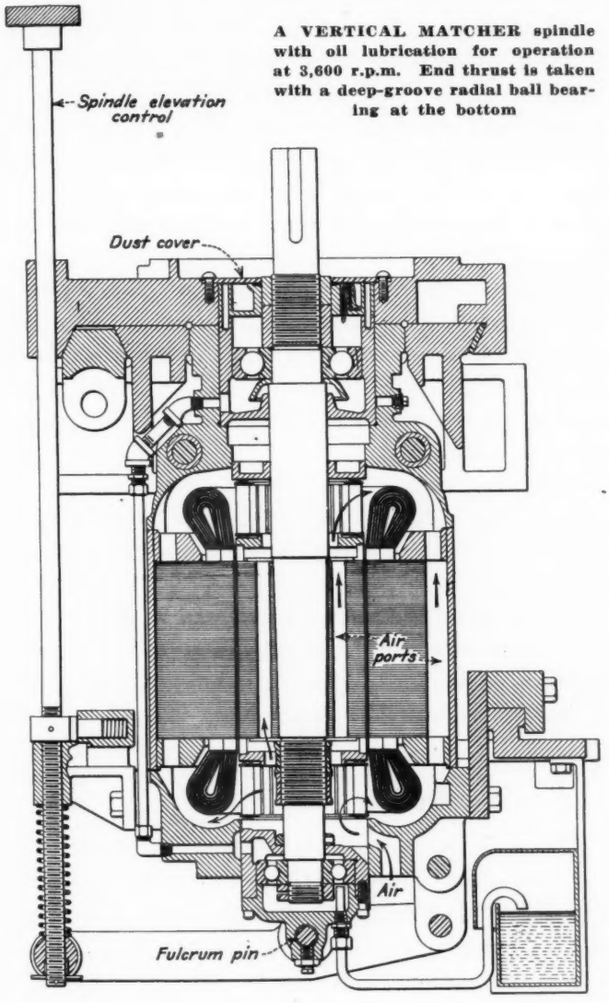
Forced ventilation is attained by two small multi-vane turbine fans mounted on the shaft, either side of the rotor. Air ports are provided in both the rotor and stator cores.

In connection with the subject of end thrust, in some cases it is necessary to pre-load the bearings in order to take out all end play. This may be done by applying spring pressure axially to the outer race of the floating bearing, it being necessary with this method that the spring pressure be heavy enough to overcome the axial thrust of the bearing caused by the radial load on the slightly displaced races, and also to exceed any working thrust loads. Another method makes use of a pre-loaded pair of bearings. This is a pair of bearings placed side by side with the inner races ground slightly narrower than standard so that when the inner races are pressed together in their mounting all end play is taken out of the assembly.

The lubrication of ball bearings at low speeds is a simple matter, but their lubrication at 3,600 r.p.m. was at first a big problem and constituted the chief drawback to their use. The usual bath of oil or housing full of soft grease was a failure because the churning of the lubricant by the ball retainer generated sufficient heat to ruin the bearing in a very few minutes. This meant controlled quantities of either oil or grease. With oil lubrication, the oil is either applied as a mist or spray, or is allowed to enter the housing drop by drop. In either case the surplus oil must be drawn off rather than allowed to accumulate and form a bath. With grease lubrications, it is necessary to use a stiff grease, one which will channel rather than flow, and it must be added in small quantites. A grease gun for example, is fatal to ball bearings at these high speeds unless used with care. In addition to being an adequate and clean lubrication, grease functions nicely as a seal for excluding dirt and moisture.

The housings for the molder spindle are typical of design for grease lubrication, which is the chief

reason for the simple closures, consisting essentially of close running clearance between shaft and housing. The vertical spindle mount is typical of one solution of oil lubrication. In this layout, the oil is contained in a covered reservoir at the top of the upper bearing housing and is allowed to reach the bearing drop by drop through a cotton wick. Much of the oil is converted into a mist which eventually condenses on the walls and collects in the bottom from where it is piped by gravity to the lower bearing. There the overflow collects in a sump with a stand pipe to maintain the level and drain the excess to a reservoir of ample capacity.



A VERTICAL MATCHER spindle with oil lubrication for operation at 3,600 r.p.m. End thrust is taken with a deep-groove radial ball bearing at the bottom

Compactness is the first consideration in the design of a cutter head. Convenience of adjustment is essential. Also, the individual parts must be strong enough to withstand the tremendous centrifugal forces to which they are subjected as well as the abuse of the average operator and the shock of operation. The peripheral speeds range up to around 10,000 feet per minute.

It is found in operation at high speeds that these cutter heads, in spite of the use of the best steels, are not rigid bodies but are rather plastic or flexible. With the best of dynamic balancing, centrifugal force still tends to deform them, or causes them to rotate about an unexpected axis. For this reason it is practically impossible to adjust a multi-knife head so that all the knives will do an equal share of the cutting. In order to make all of the knives do their part, a rather curious procedure called "jointing" has been developed. In this process, the knives are first ground to a keen edge in the usual manner. The cutter head is then rotated in the machine at full speed and under exact operating conditions and the rotating knives are brought into contact with a small stick or slab of abrasive, which is either fed across the head in the manner of an emery wheel dresser, or in the case of formed knives, is first shaped to the pattern, then fed straight in. This leaves a slightly flattened edge on the knives. Being done under operating conditions, this procedure insures that all knives will make equal contact with the wood.

ANOTHER feature of mechanical woodworking that makes designing its machinery either interesting or exasperating is the nature of the material being cut. Metal-working machinery works on a homogeneous material, and the rough stock is ordinarily quite uniform in size and shape. The rough stock from which wood products are made has hard and soft layers, cross grain, splits, knots, crooked edges, jagged ends, and warped surfaces. Furthermore, no two pieces are of the same width or thickness. Yet the feed works of a woodworking machine must push this material through in a continuous stream, without hesitation, at rates up to 700 feet per minute.

Calculations on the necessary strength of gears, shafts and bearings for machines of this type must be modified largely by the factor of experience. In fact, it sometimes seems that calculations are a waste of time, and that past experience and empirical rules are the only safe guide for the designer because the factor of shock incidental to normal operation is a large element of the total load. The vibrations are so bad that for good practice it is necessary to use lock washers or lock nuts for every fastening. In addition to these natural hazards, the operators of the machines are seldom mechanics in the sense of being competent to take care of their machines. So the machines must be capable of withstanding all sorts of abuse.

Another incident of operation that taxes the designer's ingenuity is the disposal of refuse and its exclusion from working parts. In a woodworking plant this is chips and sawdust, and in spite of exhaust systems with hoods and collectors, it pervades the atmosphere and lodges in every crevice. This is not hard to understand when we realize that each chip when it is torn loose by a cutter head and started on its travels has an initial velocity of one to two miles per minute and is difficult, therefore, to restrain. Because of this all-pervading dust, the built-in motors so common on woodworking machinery must be ventilated by what would appear to be a totally unnecessary amount of air. It is impossible to keep the dirt out; the only safe procedure is to blow it through and be sure that it goes clear through without clogging the passages.

For the same reason, all gears must be housed as carefully as ball bearings. Any troughs or pockets under moving or adjustable parts either must be avoided or must be made open bottomed so that the dust cannot pack in. Such simple oiling devices as oil holes or oil pockets for minor bearings are useless because they would be packed with impervious dust in less than a week. Where roller chain sprockets cannot be entirely inclosed, the gullets between the teeth must be gashed so that dust cannot pack in and raise the roller above the pitch line.

PRODUCT ENGINEERING

Editor: KENNETH H. CONDIT

May, 1930

. . . Necessity compels the engineer to acquire a working knowledge of all the engineering materials, and to keep in constant contact with their progressive improvement and development. . . .

—FRANCIS W. ROYS, *Professor of Mechanical Engineering, Worcester Polytechnic Institute.*

Light Weight in Moving Parts

ONE of the large American purchasers of machine tools, according to his own statement, was "astonished" to see the amount of light-weight non-ferrous alloys that are being built into the new German machines. There are no statistics on this item to compare with American machines, and apparently very little published information on the subject. But if there is anyone "falling down on the job" it is for the designers to find out and make their corrections. Putting light-weight alloys into machine-tool parts is not new, but the idea unquestionably has not gained ground as rapidly as it has in the case of automobiles and other classes of machinery.

Wherever any part has to be lifted manually, or where inertia is a factor in moving parts, especially in reciprocating or reversing motions, light-weight alloys are important, even though strength has to be sacrificed in some cases. One maker of gear shapers has employed light alloys in the reciprocating parts for several years. Overhanging weight in radial drills has also been cut down effectively by the use of light casting alloys. Other uses include splash pans and covers that must be lifted after each operation. The alert designer should study his design with this factor of lightness in mind if he is to obtain highest efficiency in his product. The item of expense may appear as an obstacle, but it is secondary, after all.

Designing Safety into Machines

LARGE SUMS are being spent regularly by manufacturing plants of all kinds in campaigns to eliminate accidents. But much of this money could be saved, or better applied, if the accidents were traced back to their fundamental sources and the machine and equipment designs were made with safety in mind.

How many industrial hazards could be traced to faults inherent in the equipment? There would be less slipping on oily floors if no oil were splashed. One authority makes the statement that eighty per cent of the oil applied to ordinary bearings actually never gets in or stays in to do useful work. There would be less accidents from mental fatigue if the noises from clashing gears, squeaky clutches, and rattling parts were eliminated by better design. There would be less fear of skin diseases from cutting compounds if the machines were fitted with means to separate the work from the chips and eliminate need for putting the hands into the liquid.

These are only a few of the safety points that should be considered by the designer. It is not sufficient for him simply to think of the obvious points such as the covering of moving parts. Before any design is finally completed it should be checked over from the standpoint of the user to see that no practical ways of making it more safe in operation have been neglected.

■

Does It Look Right?

THERE is a very old saying that if a man is radically different from others he is either a genius or is crazy, and that the chances are in favor of the latter. In many respects doesn't the same apply to machines? The chief engineer of one of the outstanding machine building plants lists as one of the tests for new designs the question: "Does it look right?" If the machine does not "look right" to experienced men, the chances are that it may not serve its purpose properly.

There is some danger of over-conservatism in this policy, but when applied with wisdom it is a fair test. The designer must recognize the fact that he has to take the consumers and users of his product as they are, and that any campaign of "education" is apt to be long and costly. It will

be recalled that when electric locomotives were first used on one of the big railroads the management ordered the controls to be designed to approximate the old steam controls in consideration of the lifetime of habit of the experienced engineers.

How far the designer can keep ahead of general practice is a matter for his judgment based on knowledge of his own field. The point is, that he should go just as far as possible if reasonably sure of the ground—and this ground must be paved with knowledge derived from research and intelligent investigation. As far as the "look right" is concerned, one automobile builder has had product artists plan the projected appearance of the product five years in advance, and from this "radical" change they have stepped back the changes to what the designers believe the buyers will accept in each new model. Visualizing ahead may be one of the best ways of calculating whether or not the product looks right from the consumers' standpoint.

It must never be lost sight of that "looks" are a big factor in sales and that the final judge as to the attractiveness or correctness of the appearance of an article is the prospect and customer. He must be satisfied regardless of any rules or laws that may dictate a specific design or appearance. Indeed, the question of appearance may often require the sacrificing of engineering efficiency.

■

Engineers as Executives

THE OFFICERS who guide our large manufacturing enterprises must, above all, be executives and financiers. But if healthy engineering progress is to be expected, the highest executives must also include men who have not only the essential fundamental requirements, but an engineering background as well. If no one with engineering experience is included among them, progress may be throttled. The officers are then in a position wherein they are called upon to pass judgment on subjects they know little or nothing about. They must bear all of the responsibility; there is no one among them upon whom to shift burdens, no one who can intelligently sift pros and cons. Ignorance breeds suspicion; good propositions are vetoed; the spirit of engineering progress is crushed; stagnation is the final result. Any business in such a situation cannot show profits, or continue to do so, for a very long period of time.

The presidents of quite a few of our largest steel companies and manufacturing concerns are men who have come up through the engineering, production, or development departments. And it is to be expected that almost every large and successful company has among its officers one or more men who have had such engineering training. The failure of many manufacturing enterprises can be traced to the fact that they were headed entirely by business men who were not engineers, or by engineers who were not business men. Both are needed.

Industrial leaders, in general, must be aware of this, because so many of them have made the statement that they are unable to find enough engineers who have developed the necessary business talents to hold the higher executive positions.

▼

New Designs for Old

SLAM the automobile door hard, the lock sticks. Bang! Ouch! Another finger smashed, and most likely a child's. Why doesn't the person closing the door first see to it that no one has his hand or fingers on the door post at the hinges? He should be more careful!

Yes indeed, care should always be exercised, but little fingers are often very quick. And why should it be necessary to have a yawning crack at the hinges when the door is open? The washroom doors in a Pullman car have covering protection strips at the hinge edges so that when the door is being opened and closed it will not be possible for anyone to get fingers caught. Why are not automobile doors fitted with similar guards?

Of course there is no crying demand for safety doors. The victims cry and that usually ends the matter. It is a human trait to say and do nothing about it afterward under such circumstances. But let one automobile manufacturer equip his cars with safety doors, then will all the past victims and their friends shout, "Why didn't they have that kind of a door before?"

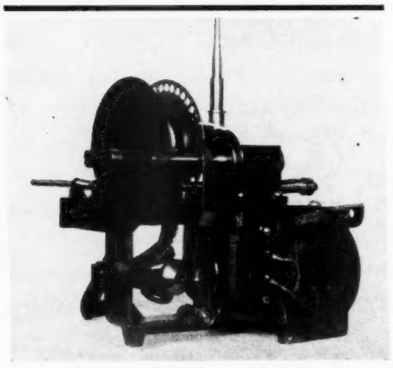
WHAT'S GOING ON—

The Month In Product Design

PHOTO-ELECTRIC cells, already being used in several hundred different types of work, have found an extension in an age-old field—that of music. There, where nothing new has appeared for a hundred years or more, the Theremin entered a year ago and already is popular. Now, Massachusetts Institute of Technology announces an entirely new method of producing musical sounds by means of light waves and a photo cell. The new instrument produces synthetic musical sounds which have never been heard before, and in addition is capable of reproducing the sounds of most existing instruments! The heart of the device is a glass disk on which are recorded photographically a number of concentric sound tracks. This disk is rotated rapidly in front of a photo-electric cell, thus generating electrical currents which are amplified and fed to a loudspeaker. Shutters, placed in front of each sound track, are operated by depressing keys on a three-octave keyboard, the pitch of each note being determined by the number of wave-forms on each sound track. This makes it possible to play in the natural, or diatonic, scale, since the key can be altered by changing the speed of rotation of the disk. The quality or timbre of the sound can be changed and loud speaker distortion can be eliminated by changing the form of the wave in recording.

DIESEL-ELECTRIC rail cars, in use less than a year in this country, are nevertheless gaining considerable popularity. The latest will be finished for the Great Northern Railway by Westinghouse sometime in August. The car is divided into engine, mail, and baggage compartments. Its 400-hp. engine will haul two passenger coaches, and uses a gallon of fuel every two or three miles.

PACKARD-DIESEL aircraft engines, recently announced, have many possibilities, according to *Aviation*. The engine is a nine-cylinder, air-cooled radial with a bore of $4\frac{13}{16}$ in. and a stroke of 6 in., giving a displacement of approximately 980 cu.in. It is rated at 225 hp. at 1,950 r.p.m. and weighs 510 lb. Outside diameter is $45\frac{11}{16}$ in. and over-all length is $36\frac{3}{4}$ in. The crankcase is the magnesium barrel, one-piece, type, and crankshaft is forged of chrome-nickel molybdenum, of two-piece construction, with pivoted counterweights. Pistons are full-skirt type, of aluminum, running in forged chrome-molybdenum cylinders with aluminum heads attached by studs. Cylinders are retained by two chrome-nickel hoops. Valves are of high-chrome silicon steel, used in connection with Venturi for both inlet and exhaust. The master rod is a one-piece forged I-section of nickel-chrome, with a removable high-lead bronze-lined steel bushing. Link rods are of I-section, forged nickel-chrome, bronze bushed.



Technidyne automatic home record changer chassis, handling twenty 10-in. records on one side only. Reject and repeat features are included

Modern art is applied to this Manning-Bowman synchronous motor operated electric clock. Motor and coil are removable and require no oiling

FUSELAGE DESIGN, so long conventional, has received an impetus with the announcement of a concave-bottom fuselage invented by a Penn State freshman. The fuselage is also arched above to reduce head resistance and increase lift. The patent issued is for a "fuselage having longitudinally and traversely arched top and bottom surfaces providing a fuselage approximating in longitudinal section and cross section the configuration of an airfoil." Advantages claimed for the new type are reduced landing speeds, added lifting power, structural simplicity, and a design which naturally adapts itself to streamlining and landing gear casing. One plane, incorporating the new fuselage, has a maximum traveling speed of 140 m.p.h. and a landing speed of only 40 miles.

AUTOMOBILE ENGINES also are being improved. A Czech engineer, Jan Sousedik, has invented an automobile, which by means of an 8-hp. gasoline motor charges accumulators with electricity and uses the reserve power thus accumulated for climbing hills or for obtaining high speeds. Meanwhile, two American inventors claim the perfection of a rotary head for internal combustion engines which eliminates cam shafts, push rods, tappets, valve springs, and similar parts. The shaft floats upon a pair of ball races and has no moving parts other than the seal keys which may be replaced easily when worn. The shaft is adaptable to other than automobile engines, and may be chain, gear, or vertical shaft driven.

ROCKET-PROPELLED, but smokeless, a rocket car has been demonstrated in Berlin by Herr Max Valier, well-known inventor. The car uses a new principle of propulsion, using liquid gas. The principle rests on the fusion of liquid oxygen and water and methylated spirits. The fuels are carried in separate tanks in front of and behind the driver as a protection against explosion, and are fed through twin conduits to a tube 18 in. long and 2 in. in diameter with a small opening having a function similar to that of the carburetor, but acting more like a blowpipe. The car is driven by the blowpipe flame escaping in the familiar rocket principle, but it is a smokeless flame and the car can be stopped almost instantly.

AUTOMOBILE RADIO, in spite of the objections of state officials and others, seems to be gaining considerable headway. Among the dozen sets now being made for automobile installation are few differences in design, all being of standard construction, using sensitive radio frequency amplifiers, detector, and audio amplifier, as does the regular home set. Practically all models are designed for mounting behind the instrument board, tuning being controlled by a remote

control dial, antenna being built into the top of the car, and loudspeakers being mounted on the dash and protected by a wire mesh. Batteries are stowed in special containers under the floorboards or beneath the seat.

ELECTRICAL EQUIPMENT new this month, according to *Electrical Merchandising,* includes a toaster, built by the Electro Manufacturing Company, which toasts two slices at once, ejecting them automatically onto a convenient plate when done. The current also is shut off automatically and the toaster is silent in operation since it has no clockwork mechanism. It is finished in chromium plate, trimmed in black, nile green, or chinese red. Another of the table-type ironers, being announced by the Conlon Corporation, is fully automatic in operation and has a kitchen table top with special process baked-on lacquer. The same company is producing a washer with a tub of mottled porcelain fused on Armco ingot iron. This inner tub is armored by an outer annealed steel shell, the double tank providing thermos type insulation claimed to keep the water hot 40 per cent longer. The outer annealed sheel is lacquered in Nyanza green, and the machine is equipped with non-rusting cadmium-plated, steel frame wringer.

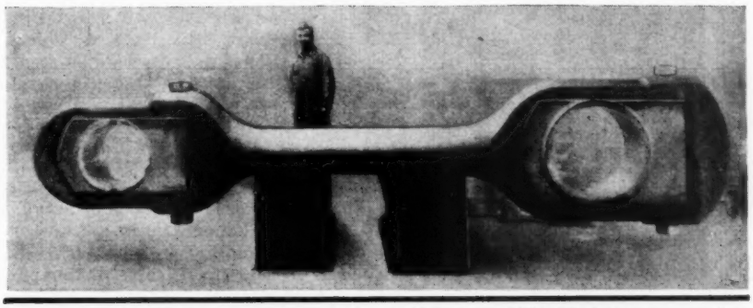
LATHE DESIGN, long leaning toward hydraulic control and drive, has now achieved that end. The automatic hydraulic lathe announced in *American Machinist* by the John S. Barnes Corporation has hydraulic feed and control, clockwise rotation of the spindle, and chain drive. The feed is hydraulic on both rear and front carriages, the front carriage rotating on a large shaft to feed, and being traversed by longitudinal shaft movement. An unusual rate of metal removal per hp.-hour is claimed. A hydraulic power saw is announced by the Racine Tool & Machine Company, embodying greater feeds at the top and bottom of rounds to give more uniform penetration and faster cutting time. A tube welder using d.c. instead of a.c. current prevents stitches in the weld and provides its own d.c. by using two 35-hp. motors to drive a rotating d.c. generator. The frame rotates slowly and rings on the outside at center deliver the current and roll the tube edges together.

COTTON-PICKING MACHINERY has undergone several changes in evidence at the recent Boston Exhibition, according to *Textile World.* A Ramsdell calender automatically doffs the full lap on the picker and inserts a new lap rod without stopping the machine. An improved one-process picker was exhibited by the Within Machine Works, which was equipped with a reserve-box feeder driven through the evener box, a 24-in. downstroke Buckley beater provided with 80 adjustable grid bars and a noiseless beater drive. A machine incorporating carding and garnetting principles and eliminating the garnetting process was shown by Proctor & Schwartz.

A Glance Over the Pages—

1. ***What is the vital factor in disk clutch design? p. 210***
2. ***What are the present trends in aviation design? pp. 230 and 243***
3. ***How may mottling be prevented in malleable iron castings? p. 214***
4. ***What engineer has been recognized recently for social service? p. 240***
5. ***How is color obtained in molded parts? p. 228***
6. ***When are specifications drawn up in machine-tool development? p. 220***
7. ***How should materials be marked? p. 219***
8. ***How is belt horsepower calculated graphically? p. 250***
9. ***What is the first step in laying out spider gearing? p. 208***
10. ***What is the unusual feature in the design of woodworking machines? p. 222***

Propellor, 42 in. in diameter, arc-welded by Westinghouse for large blower. Driven by a 300-hp., 3,520 r.p.m. motor, it will "blow" 100,000 cu.ft. per minute



The 15-ton connecting rod for a 10,000-hp. Allis Chalmers gas engine designed to handle stresses of 800,000 lb. at the moment of explosion

News of the Metal Markets

COPPER, despite the recent drops to 13 cents after a year at the 18-cent level, has not enhanced its market materially in the opinion of *Metal & Mineral Markets.* Because of the persistent rumors of another cut in price, this time to 12 cents, buying is of the hand-to-mouth variety, and export sales are small. Fabricators are buying only as they must to maintain production, since world stocks of copper are still far too great to make mining profitable.

LEAD is also selling dully, both in the domestic and export markets. Users are taking only about two-thirds of the quantity usually taken at this time, due no doubt to the uncertain state of the market and the decreased needs for this bearing metal base in production. The price is unchanged at 5.50 cents a pound, about 20 per cent above that of zinc.

ZINC, selling at 4.70 cents, has struck a new low for the year. Production has been curtailed, but users are still sure enough of the stock on hand to be buying only as the metal is needed in production. Galvanizers are showing little interest, and producers are none too willing to push sales at the present low price. It is thought that figures for April domestic production of zinc will show a decline compared with March. One large group of producers of zinc in this country is understood to have reduced its production about 10 per cent in the last few weeks.

TIN prices also experienced a further decline during the month, selling now somewhere around 33 cents a pound. Stocks of this plating and bearing metal are still high, and much of the production curtailment talk has been found to be misleading. The Department of Commerce considers world tin reserves to be sufficient for many years to come, in spite of increasing quantities being used by the canning and automobile industries, now using about 40 per cent of the world's virgin tin production, about 99 per cent of that used in this country being imported.

SILVER is steady at about 42 cents an ounce. The Chinese situation has steadied somewhat and the price is expected to remain about where it is, but platers and other users are showing little interest beyond immediate requirements.

BERYLLIUM, exceedingly rare but only half as heavy as aluminum, which, in alloys, greatly increases the hardness, longevity, and stability of other metals, is dropping in price. Selling at about 1,500 marks per kilogram at the beginning of 1929, the price is now around 900 marks. The market is expanding steadily and uses are being found outside the electrical industry.

IN THE SPOTLIGHT—

AMBROSE SWASEY, chairman of the board, Warner & Swasey Company, Cleveland, Ohio, was recently awarded the City of Cleveland's medal for public service. The award was made by the Cleveland Chamber of Commerce at its annual meeting in April, and Mr. Swasey's name was one of three which were added to the list this year. Tribute was made in connection with the award in the following citation:

Generous supporter of charitable, educational, civic, and scientific institutions of Cleveland, and of the nation.

Authority on instruments of precision.

Inventor and builder of unique scientific instruments which have essentially added to human knowledge and welfare.

Holder of the highest scientific honors: Member of the National Academy of Sciences, Fellow of the Royal Astronomical Society, Chevalier Legion d'Honneur, founder-member and past-president of the American Society of Mechanical Engineers, member of the British Institute of Mechanical Engineers.

A distinguished citizen who is honored not only in this country, but also throughout the civilized word; whose character and achievements shed glory and honor upon the City of Cleveland.

R. J. ALLEN, for the past 12 years metallurgical engineer with the Rolls-Royce Company of America, Springfield, Mass., has accepted a position as research engineer with the Worthington Pump & Machinery Corporation, Harrison, New Jersey.

ANDRE ATTENDU, who was consulting engineer of the Attendu Engines Company, Montreal, Canada, has established offices at 266 St. James St., West, Montreal, as a consulting engineer.

RUSSELL S. BEGG, until recently chief engineer of the Stutz Motor Car Company, Indianapolis, Ind., has been appointed chief engineer of the Midland Steel Products Company, Cleveland. He will direct the company's engineering activities, including its new experimental laboratory.

VINCENT BENDIX has been elected president and a director of the newly formed Bendix-Westinghouse Automotive Air-Brake Company, recently formed jointly by the Westinghouse Air Brake Company and the Bendix Aviation Corporation.

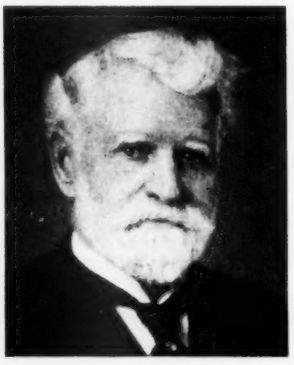
M. C. BAUMANN, who recently became consulting engineer for the Mercury Aircraft Corporation and the Inland Aviation Company, Kansas City, Kan., was previously chief engineer for the Butler Aircraft Corp., Kansas City.

JOHN BODE, formerly engineer for the Mackintosh-Hemphill Company, Pittsburgh, and more recently identified with the Wellman Engineering Company, Cleveland, is now affiliated with the sales department of the Aetna-Standard Engineering Co., Youngstown.

HAROLD CAMINEZ of the Aircraft Engine Division, Allison Engineering Company, Indianapolis, Ind., will present a paper entitled "Trends in Aircraft Developments" at the Dayton Aeronautic Meeting of the A.S.M.E.

HERBERT A. CARHART has become an engineer with the Barr-Morse Corporation, Ithaca, N. Y. Mr. Carhart was with the Remington Typewriter Company at the Syracuse plant for 20 years, and during the World War was with the Lincoln Motor Company, Detroit, on Liberty motors. He has also taken out a number of patents on typewriter improvements.

M. L. CARR, formerly identified with Barrington Associates of New York City, has been appointed staff engineer of the Pittsburgh Testing Laboratory.



Ambrose Swasey

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A. J. Lyons

●

S. M. Kintner

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PROF. G. L. CLARK of the University of Illinois, gave a talk on the use of the X-Ray in the examination and inspection of metals at the May 8 meeting of the St. Joseph Valley section of the A.S.M.E.

WALLACE CLARK, consulting engineer of New York, Paris, Prague, and Warsaw, returned to Paris on May 7, after a one month's visit to the United States. He expects to be gone for six months.

F. G. COBURN, a member of the engineering firm of Sanderson & Porter, has been elected president of the Aviation Corporation of Delaware, according to a recent announcement. He will succeed GRAHAM B. GROSVENOR, who has become vice-chairman of the board of directors.

DR. CLAUDE DORNIER, designer of the Dornier DO-X flying boat, Friedrichshafen, Germany, will present a paper entitled "The Design of Giant Flying Boats" at the Dayton Aeronautic Meeting of the A.S.M.E., May 19 to 22.

LIEUT. HUGH C. DOWNEY, former assistant engineering officer at France Field, is now chief engineering officer.

HAROLD G. DRYSDALE, consulting engineer of Brooklyn, N. Y., gave a talk on "Engineering Problems of Servicing Airplanes" at the May 8 meeting of the Metropolitan Section of the A.S.M.E. This was a joint meeting, held in New York City, with the Aeronautical Chamber of Commerce, in connection with the New York Aviation Show.

DR. G. H. GILLETT of the Battelle Memorial Institute, Columbus, Ohio, will present a paper entitled "Some Characteristics of Light Alloys for Aeronautics" at the Dayton Aeronautic Meeting of the A.S.M.E., May 19 to 22.

FRED C. GOLDSMITH has joined the Hinderliter Tool Company, Tulsa, Oklahoma, as engineer. He was formerly engineer and general superintendent of the W-K-M Company, Inc., Houston, Texas.

RALPH R. GRAICHEN has become an aeronautic engineer with Gazley & LaSha, consulting engineers, City of Washington. He was previously vice-president and chief engineer of the Metal Aircraft Corporation, Cincinnati.

DAVID GREGG has become an engineer in the organization of the Eclipse Aviation Corporation, East Orange, N. J. Three years ago he became engineer with the A C Spark Plug Company, Flint, Mich. In 1929 he entered the Delco-Remy organization, where he remained until his recent resignation.

WILLIAM B. GREGORY, professor of experimental engineering and hydraulics, Tulane University of Louisiana, was recently promoted to the grade of colonel in the Engineer Reserve, U. S. Army. Colonel Gregory served as a major of engineers in the A.E.F., and was at one time a vice-president of the A.S.M.E.

EUGENE HAHN, developer of a line of bulk material handling and storage equip-

ment, has joined the Treadwell Engineering Company, Easton, Pennsylvania.

EDWARD HANAK, Houston, Texas, is well known in industrial circles throughout the United States and in foreign countries as an inventor of mechanical devices and equipment, but the fact is not generally known that he is blind and that several of his notable inventions have been designed and built since he lost his eyesight five years ago. Mr. Hanak specializes in the invention and construction of automatic conveying and stacking machines, truck and platform hoists, interior trolley systems, and similar devices, some of them involving 300 or more moving parts.

RUSSELL S. HARDY, chief engineer, the Waco Aircraft Company, Troy, Ohio, will present a paper entitled "Design of Airplanes from the Point of View of Cheap Production" at the Dayton Aeronautic Meeting of the A.S.M.E., May 19 to 22.

EARL E. HODIL has been appointed chief draftsman for the Thomas Spacing Machine Company, Pittsburgh, Pennsylvania.

STEPHEN JOHNSON, JR., was recently transferred from the Chicago office of the Westinghouse Air Brake Company, where he was service engineer, to the Pittsburgh factory, where he is acting as general engineer in the automotive brake division.

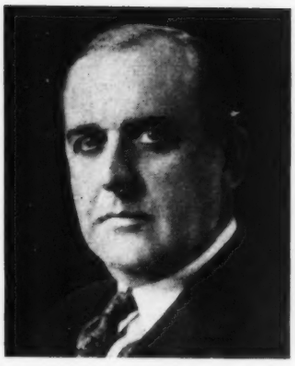
WILLIAM E. KEMP, formerly Detroit district sales manager of the Kingston Products Corporation, Kokomo, Ind., has been named vice-president in charge of engineering at the company's Kokomo plant.

W. B. KOCHENDERFER, formerly in charge of engineering and sales for the Lake Erie Engineering Corporation, Buffalo, was recently appointed chief engineer of the hydraulic machinery department of R. D. Wood & Co., Philadelphia.

VICTOR A. LARSEN, until lately structural engineer working in stress analysis, for the Commercial Aircraft Company of America, Bridgeport, Conn., is now a draftsman for the Sikorsky Aviation Corporation of the same city.

CHARLES L. LAWRANCE, formerly president of the Wright Aeronautical Corporation, has become vice-president of the Curtiss-Wright Corporation in charge of research and engineering. Mr. Lawrance developed the Wright Whirlwind radial, nine-cylinder, air-cooled engine. ARTHUR NUTT, chief motor engineer of the Curtiss Aeroplane & Motor Company, was made vice-president of the Wright Aeronautical Corporation, and FRANK H. RUSSELL, for many years vice-president of the Curtiss Aeroplane & Motor Company, was named a vice-president of the Curtiss-Wright Corporation. GUY W. VAUGHAN has been elected president of the Wright Aeronautical Corporation.

A. J. LYON, first lieutenant, Air Corps, Wright Field, Dayton, Ohio, will present a paper entitled "Aluminum Alloys for Pistons and Air-cooled Cylinder Heads for Aircraft Engines" at the Dayton Aeronautic Meeting of the A.S.M.E. from May 19 to 22.



E. D. Kilburn

W. S. Rugg

Russel S. Hardy

Harold Caminez

GEORG H. MADELUNG was recently appointed a professor at the Stuttgart Institute of Technology. Previous to this appointment he was vice-president in charge of research at the German Institute for Aeronautical Research and a professor at the Charlottenburg Institute of Technology.

G. PHILLIPS, who has been employed as an experimental engineer by Lubrication Devices, Inc., Battle Creek, Mich., has entered the engineering department of E. C. Stearns & Co., Syracuse, New York.

PROF. F. L. PRESCOTT, research mechanical engineer of the Power Plant Branch, Materiel Division, Wright Field, Ohio, will present a paper entitled "Vibration Characteristics of Aircraft Engine Crankshafts" at the Dayton Aeronautic Meeting of the A.S.M.E., May 19 to 22.

CARL F. RAUEN, until lately assistant aeronautical engineer in the Materiel Division, Wright Field, Dayton, Ohio, is now connected with the Detroit Gear & Machine Company, also of Dayton, as an engineer.

H. W. REED has become works manager of the Shaw Crane Works, Muskegon, Mich., of Manning, Maxwell & Moore, Inc., New York, to succeed HENRY HUSS, resigned. Others identified with the plant administration are: JOHN MINTY, chief engineer, J. L. HAGA, estimating engineer, J. C. HARTH, assistant chief engineer, and GAIL MAZE, assistant estimating engineer.

LEWIS H. REID has been made chief engineer in charge of research and development of the Magnetic Analysis Corporation, Long Island City, N. Y. He was formerly chief metallurgist for the American Cirrus Engine Company, Marysville, Michigan.

JOHN R. REPLOGLE was recently made chief engineer of Copeland Products, Inc., Mt. Clemens, Mich. He was formerly chief engineer of the Nizer Corporation and before that was with the Kelvinator Company.

FRANK RIFFLE, European director of engineering and sales in Paris for the Kearney & Trecker Corporation, Milwaukee, has returned to the United States to become Chicago office manager.

W. S. RUGG, vice-president in charge of engineering of the Westinghouse Electric & Manufacturing Co., East Pittsburgh, has been placed in charge of engineering and sales activities, succeeding EDWARD D. KILBURN, who has resigned to enter private practice as a consulting engineer. Mr. Rugg has been associated with the Westinghouse Company since 1892, and was elected vice-president in charge of engineering in 1925. S. M. KINTNER, director of the Westinghouse Research Laboratory, has been made assistant vice-president and assumes engineering department duties under Mr. Rugg.

W. M. SCARTH, formerly assistant specification engineer for the General Motors Company, Oshawa, Ontario, has resigned to become assistant research engineer for the Auburn (Ind.) Automobile Company.

WILLIAM SCHROEDER recently resigned from the Western Electric Company, Kearny, N. J., where he was materials-handling division department chief, to join the Mercury Manufacturing Company, Chicago, as chief engineer.

CLIFFORD W. SMITH, formerly layout draftsman for Dietrich, Inc., Detroit, is now a body-layout draftsman for the H. H. Franklin Manufacturing Company, Syracuse, New York.

P. B. TAYLOR, acting chief engineer of the Wright Aeronautical Corporation, Paterson, N. J., will present a paper entitled "Installation of Air-Cooled Radial Engines" at the Dayton Aeronautic Meeting of the A.S.M.E., on May 22.

W. TAYLOR has resigned as chief engineer for the Scripps Motor Company, Detroit, to become a marine engineer for the Lycoming Manufacturing Company, Williamsport, Pennsylvania.

JAMES M. TODD, consulting engineer of New Orleans, La., was recently installed as president of the Louisiana Engineering Society. Mr. Todd served as vice-president of the A.S.M.E. last year, and is a member of the board of directors.

J. F. WALLACE, chief engineer of the Cleveland Pneumatic Tool Co., and designer of the first pneumatic shock-absorbing strut for aircraft, has gone to Europe. He will join L. W. GROVE, acting head of the company, at Berlin, and will visit European aircraft manufacturing establishments.

RONALD J. WATERBURY, who recently became a body research engineer for the Chevrolet Motor Company, Detroit, Michigan, was previously assistant general manager for the Central Manufacturing Company, Connersville, Indiana.

F. L. Prescott

J. R. Replogle

J. G. PEARCE, director and secretary of the British Cast Iron Research Association, has been chosen to present the annual exchange paper of the Institute of British Foundrymen before the May meeting of the American Foundrymen's Association. Mr. Pearce's paper will be on Correlation of Tests for Cast Iron, a subject on which he is one of the world's foremost authorities.

COMM. EUGENE E. WILSON has resigned from the U. S. Navy after twenty years of engineering activity.

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The recently created Scientific Advisory Board of the Westinghouse Research Laboratories, made up of five leading scientists from the universities of the East and Middle West, is to confer with Westinghouse research engineers on scientific developments. The members are shown above, at their first meeting with S. M. Kintner (left), director of the laboratories. The others, left to right, are: Dr. G. B. Waterhouse, head of the department of metallurgy at the Massachusetts Institute of Technology; Dr. Stephen Timoshenko, head of the school of advanced mechanics at the University of Michigan; Dr. Edward Mack, Jr., professor of physical chemistry, Ohio State University; Dr. P. W. Bridgman, head of the department of physics at Harvard University, and Dr. C. E. Mendenhall, head, department of physics, University of Wisconsin.

Meetings

American Foundrymen's Association—Annual Convention, Cleveland (Ohio) Public Auditorium, May 12-17. C. E. Hoyt, 222 W. Adams St., Chicago, secretary-treasurer.

American Society of Mechanical Engineers—Semi-Annual Meeting, Hotel Cadillac, Detroit, June 9-12. Calvin Rice, 33 West 39th St., New York City, secretary.

American Society for Testing Materials—Annual Meeting, Haddon Hall, Atlantic City, N. J., June 23-27. C. L. Warwick, 1315 Spruce St., Philadelphia, Pa., secretary.

Association of Iron & Steel Electrical Engineers — Annual Convention and Exposition, Broadway Auditorium, Buffalo, N. Y., June 16-20. John F. Kelly, Empire Bldg., Pittsburgh, Pa., managing director.

International Congress for General Mechanics—Liege, Belgium, Aug 31-Sept. 7. For information address Alb. Schlag, 4 Place Saint Lumbert, Liege, Belgium.

Society of Automotive Engineers—Summer Meeting, French Lick Springs Hotel, French Lick Springs, Ind., May 25-29. C. F. Clarkson, 29 W. 39th St., New York, N. Y., secretary.

Radio Manufacturers' Association Convention and Trade Show—New Atlantic City (N. J.) Auditorium, June 2-8. G. Clayton Owens, Radio World's Fair, 1904 Times Bldg., New York City, in charge.

Obituaries

EDWIN H. LOCKWOOD of Yale University, one of the foremost mechanical engineering experts in this country, died on April 16, at the New Haven Hospital, of heart disease. He was born in 1865.

CAPT. LIONEL M. WOOLSON, Army Air Reserve, chief aeronautical engineer of the Packard Motor Company and inventor of the Packard Diesel aircraft engine, was killed on April 23.

HARRY S. GRAVES, 46, formerly chief engineer of the Oakland Motor Car Co., died of a heart attack at his home in Detroit on Feb. 14.

WILLIAM E. BLAIR, Buffalo, nationally known authority on gas engine design, died recently. He is said to have designed the first V-type motor built in this country.

FRANK D. WARREN, engineer, died May 5 at his home in Newton Highlands. He was 50 years of age, and for the last eleven years was head of the Warren Engineering Corporation.

DOUGLAS SPRAGUE, 69, consulting engineer of New York City for many years, died at his home in Mt. Vernon, N. Y., on April 17.

ALEXANDER B. FERNALD, 85, inventor of a machine for manufacturing carbon paper, died at his home in Mt. Freedom, N. J., on April 18. He retired from business about 32 years ago.

FRED M. LOCKE, 69, inventor of the porcelain insulator and oven glass, died in Victor, N. Y., on April 15. Mr. Locke retired from business in 1904.

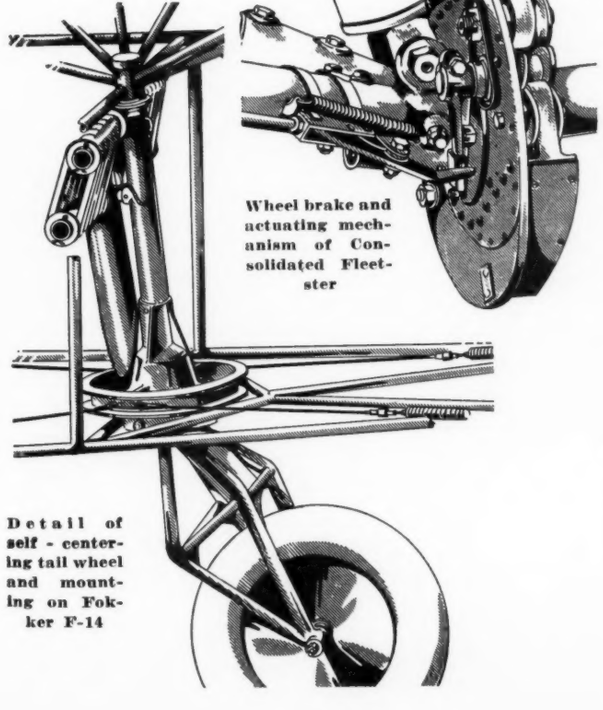
Research and Engineering in the Capital

By PAUL WOOTON
Washington Correspondent

AT THE request of the War Department, the Bureau of Standards has undertaken an investigation of white metal bearing alloys with a view toward lessening and, if possible, eliminating the tin and antimony requirements in these alloys at least for many types of service. The plans as outlined provide for a study of the general types of bearings described by the American Society for Testing Materials and Society of Automotive Engineers specifications. In addition to these a number of new combinations of alloys will be studied. The specimens which are being tested are prepared in the laboratory under carefully regulated conditions so as to reduce to a minimum the variables which are ordinarily encountered in mechanical testing.

The various alloys are being tested for the determination of (1) resistance to wear, (2) resistance to pounding, (3) resistance to compression, (4) hardness, and (5) toughness. These tests are conducted at room and elevated temperatures. Following the completion of the laboratory tests various alloys which have been investigated will be subjected to service tests supervised by the War Department.

Under the stress of present conditions, a temporary recession is evident in the interest of manufacturers in scientific and industrial research work. This reaction is keenly felt in Washington because of the close contact that has been maintained, particularly in recent years, between industrial and trade organizations and Government scientists and economists. The Government frequently is a co-operator in industry-wide projects concerning some phase of production or distribution that are carried forward actively when plants are in full swing and payrolls are fat.



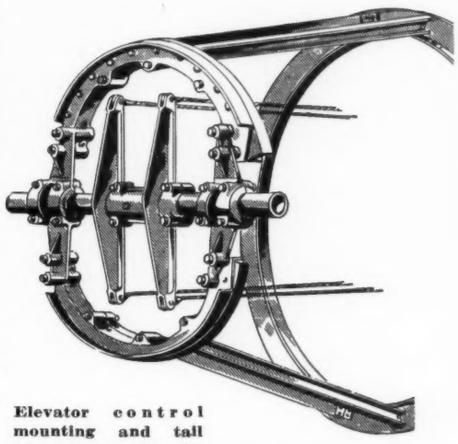
Wheel brake and actuating mechanism of Consolidated Fleetster

Detail of self-centering tail wheel and mounting on Fokker F-14

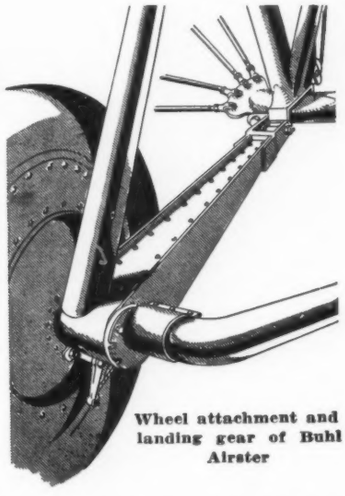
Developments In Airplane Design

EVIDENCE of the gradual transition from wood to metal in plane construction was the most striking characteristic of the Detroit Aviation show in April, according to *Aviation*. Notable examples are the all-metal fuselage of the Lockheed Vega and the welded steel and aluminum alloy tube wing structure of the Stimson Airliner. While the majority of metal structures employed riveting or welding, two water craft, the Eastman Flying Boat and the Keystone Loening Commuter, had bolted hull structures.

As shown in the accompanying table, most recent designs in planes include an ever increasing number of seaplane and amphibion types. The problem of engine location and power distribution does not seem to be settled for this type of craft.



Elevator control mounting and tail structure of all-metal Lockheed Vega



Wheel attachment and landing gear of Buhl Airster

AIRPLANE DESIGN TRENDS	Detroit Show 1929		Cleveland Show		St. Louis Show		Detroit Show 1930	
	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent
Total planes entered	100	..	56	..	84	..	75	..
Monoplanes	48	48	33	59	44	52	45	60
Biplanes	47	47	21	37.5	37	44	29	39
Convertible	1	1	0	0	0	0	0	0
Sesquiplanes	4	4	2	3.5	3	4	1	1
Open planes	53	53	31	55	41	49	47	63
Closed planes	47	47	25	45	43	51	28	37
Land planes	95	95	51	91	75	89	68	91
Seaplanes, flying boats	3	3	3	5	5	6	3	4
Amphibions	2	2	2	3.5	4	5	4	5
Single engined	95	95	49	87	79	94	67	89
Twin engined	1	1	2	3.5	2	2	2	3
Three engined	4	4	5	9	3	4	5	7
Four engined	0	0	0	0	0	0	1	1
One place	4	4	4	7	6	7	2	3
Two place	32	32	19	34	23	27	28	37
Three place	29	29	13	23	24	28	13	17
Four place	11	11	5	9	12	14	12	16
Five place	5	5	2	3.5	2	2	0	0
Six place	9	9	8	14	7	8	9	12
Seven place	2	2	0	0	3	4	0	0
Eight place	5	5	1	2	3	4	6	8
Twelve or more	3	3	3	5	4	5	5	7
Radial engined planes	90	90	51	91	72	86	59	79
Vertical in line air cooled	10	10	5	1	5	6	5	7
Opposed	..	..	..	..	1	1	1	1
Inverted in line air cooled	..	..	..	..	1	1	2	3
Water cooled (other than OX-5)	..	..	..	..	2	2	0	0
Diesel	..	..	..	..	..	..	6	8
OX-5	9	9	0	0	3	4	2	3
0-50 hp	3	3	1	2	3	4	2	3
50-150 hp	50	50	22	40	27	32	26	35
150-200 hp	14	14	11	20	17	20	4	5
200-300 hp	11	11	11	20	18	21	15	20
More than 300 hp	27	27	11	20	16	19	28	37

NEW MATERIALS AND PARTS AND ENGINEERING EQUIPMENT

"G-M" Sensitive Relay

PHOTO-ELECTRIC reactions are converted into electrical impulses by means of a sensitive relay announced by the G-M Laboratories, Inc., Grace & Ravenswood Aves., Chicago, Ill. These electrical impulses permit the operation of auxiliary apparatus. The G-M sensitive relay is complete in itself, as it embodies a one-stage amplifier using a standard UX 199 tube, which makes possible sensitivity to as minute a change in light intensity as 0.005 lumen.

This sensitive relay can be used for a wide range of duties in connection with photo-electric cells, some of them being the counting of moving objects, the grading of materials according to color, the inspection and testing of new and finished products ordinarily performed by an operator.

Sensitive relay for photo-electric cell to operate auxiliary apparatus

■

Boston Light-Duty Speed Reducers

THREE TYPES of light-duty speed reducers have been placed on the market by the Boston Gear Works Sales Company, North Quincy, Mass. All of these reducers are especially adapted to the transmission of light loads under continuous operation. They have a hardened steel worm with a phosphor-bronze worm gear, and are equipped with Timken tapered roller bearings throughout.

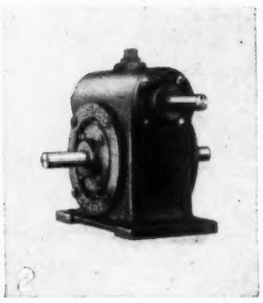


Fig. 1—Boston Type AB Worm Gear Speed Reducer of ⅛ hp. capacity. Fig. 2—Type UC Light-Duty Worm Gear Reducer of ⅛ hp. capacity

The Type AB reducer, Fig. 1, has the gear shaft over the worm shaft, and will transmit $\frac{1}{6}$ hp. with the motor running at 1,800 r.p.m. Ratios are 5 to 1, 10 to 1, and 20 to 1. The Type AD is similar to the type AB, but is especially adapted to installations requiring the use of a $\frac{1}{4}$-hp. motor running at 1,800 r.p.m. Ratios in this model are 9 to 1, 18 to 1, 36 to 1, and 58 to 1. A third model, Type UC, has the worm shaft over the gear shaft and is of $\frac{1}{8}$-hp. capacity, the motor running at 1,800 r.p.m. A ratio of 48 to 1 is available. The Type AB weighs 8 lb., the Type AD, 13 lb. and the Type UC, 8 pounds.

■

"Keldur" Vibration-Insulating Board

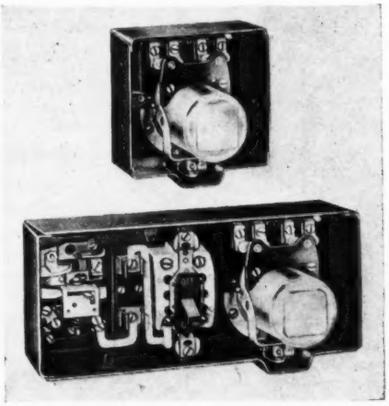
DEADENING noise and vibration is met by "Keldur," a board-like product recently put on the market by the International Products Corporation, 425 Van Buren St., Milwaukee, Wis. This rubber-like material, unlike rubber, is not affected by oil and will not harden. It possesses durability against mechanical and chemical disturbances and will retain its elasticity indefinitely.

The material can be used for either light or heavy equipment where noise and vibration are to be held at a minimum. It comes in sheets 28 x 36 in. or 29½ x 40½ in., and in thicknesses of $\frac{1}{4}$, $\frac{3}{8}$, and $\frac{3}{4}$ in. Ordinary practice is to cut the material into strips to conform to the frame of the machine to be insulated, and attach it to wooden strips.

■

Allen-Bradley Automatic Pressure Switch

FOR STARTING and stopping compressors and pump motors, the Allen-Bradley Company, 286 Greenfield Ave., Milwaukee, Wis., has announced its Bulletin 830 pressure switch. The design of the pressure switch follows new lines and is about the size of a small outlet box.



Automatic pressure switch unit at the top. Below—switch mounted with other control devices

The Size B pressure switch is made in four forms in various combinations with or without overload breakers, disconnect switches, and fuse clips. This unit is rated at 1 hp. on 110-220 volts d.c., and 1 hp. for 110 volts, and 2 hp. at 220 volts, on a.c. circuits.

The Size C switch is rated up to 5 hp. For larger ratings, the Size B pressure switch is used as a pilot control for magnetic starters.

■

"Prismlac" A Decorative Lacquer

SIMPLICITY and rapidity of application coupled with an unusual decorative effect are features of the "Prismlac" lacquer developed by the Maas & Waldstein Company, 438 Riverside Ave., Newark, N. J. Polished or smooth brass parts can be given a distinctive finish in one coat

"Prismlac" Lacquer as applied to a polished brass part. It air dries in one hour

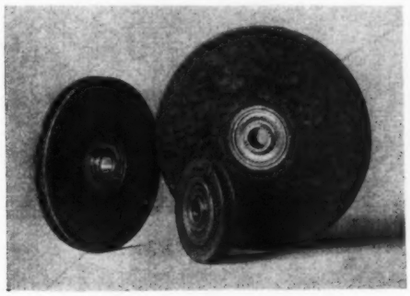
that will air dry in one hour. Moreover, in solid colors "Prismlac" will entirely obliterate such defects as drawing marks, spot welds, or file marks on stamped steel parts, as for example, radio chassis and cans. The material is available in clear lacquer, colors, and bronze finishes.

"Prismlac" air dries in about one hour. It is sprayed on and crystallizes almost immediately.

■

"Micarta" Ball-Bearing Pulleys

CONTINUED refinement in airplane design has prompted the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., to offer a "Micarta" pulley with an anti-friction bearing. This type supplements the model having a graphite impregnated bearing as supplied for some time. It is claimed that the anti-friction pulley will satisfy exacting requirements of strength, durability, and low running friction. Since the load imposed may be up to 300 lb., there are, besides aircraft, many



Bearing loads of 300 lb. can be sustained by this pulley

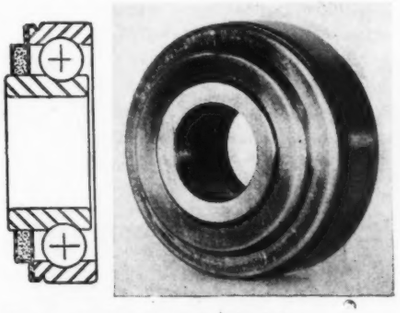
other applications on delicate machinery or for many common every day devices requiring pulleys to transmit light loads.

In manufacturing this pulley, a brass bushing with a knurled outer surface is anchored in the "Micarta" body during the molding operation. It is then reamed to size, and the grease-packed bearing is inserted in place and swedged over to prevent loosening. When correctly installed in protected positions on aircraft, this bearing will operate indefinitely.

■

Fafnir Felt-Seal Bearing

ADEQUATE closure is the feature of the standard felt-seal ball bearing announced by the Fafnir Bearing Company, New Britain, Conn. A



Bore and diameter of this felt-seal bearing are standard, but the width is slightly greater

pressed steel shell is permanently fitted over one face of this bearing and shaped so as to contain a felt ring or washer. The bearing inner ring is wider than normally, and thus allows the felt ring to bear closely on it to seal the bearing against dirt or escape of lubricant. The thin sheet steel washer placed between the bearing and the felt holds the latter firmly in place against the outer shell and also aids in sealing.

To prevent loss of efficiency, the felt seal is fitted closely around the inner ring, but not so tightly as to cause friction. The steel outer shell, likewise, is fitted into a groove in the outer ring so that there is no interference with the hardened and ground surface of the outside diameter.

Ten sizes of this felt-seal bearing are now available for such applications as portable tools and electric motors. These include the 30 series and smaller members of the 200 series, the suffix J being used after the bearing number to designate the type. The capacity is equivalent to the corresponding single-row bearing, and the bore and outside diameter are of standard dimensions, but the over-all widths of the felt-seal bearings are slightly greater. Among the advantages claimed are: reduced machining costs; efficient lubrication; greater compactness, and easier assembly.

■

"Lubri-meter" Automatic Viscosimeter

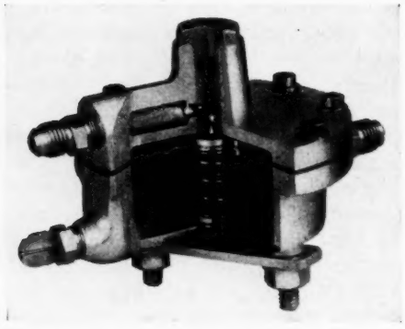
DEFINITE knowledge concerning the viscosity of a lubricant under operating conditions, either in an internal conbustion engine or in a complex machine, may be obtained by the use of a "Lubri-meter," an automatic viscosimeter developed and placed on the market by the American Viscosimeter Company, Inc., 110 E. 42nd St., New York, N. Y. This device actually consists of two parts, a direct-reading gage or instrument dial and the automatic viscosimeter itself. It is claimed to give information approximating the true physical viscosity more exactly than does the Saybolt viscosimeter, and this is done instantaneously. Thus an operator can constantly check the condition of

Dial Gage for the "Lubrimeter"

NEW MATERIALS AND PARTS

the oil employed in the engine or machine and change it when a dangerous limit has been reached.

The instrument consists essentially of an ordinary pressure gage measuring the head set up by oil flowing through a friction tube at a rate held constant by a diaphragm and ball check arranged somewhat as in an ordinary reducing valve. The seating of the ball valve is controlled by



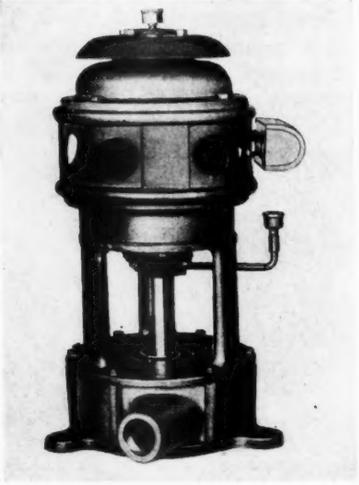
Sectioned "Lubri-meter," revealing the diaphragm, ball check valve, and calibrated tube

a point on the diaphragm button, while oil can flow between the ball and its seat into the space above the diaphragm. The latter has a small calibrated hole through which oil can get underneath the diaphragm and from thence to the calibrated outlet tube at the left. The space between the diaphragm and the outlet is connected to the pressure gage at the right, whose readings measure the true viscosity with a degree of precision considerably higher than that called for by most practical conditions. The gage shows the friction head proportional to the viscosity of the oil. It is possible to calibrate the dial to read in Saybolt seconds.

■

Ruthman Vertical Coolant Dump

DESIGNED to be built directly into a machine or mounted upon a suitable baseplate, the Model A-L two-stage coolant pump has been added to the line manufactured by the Ruthman Machinery Company, Cincinnati, Ohio. This pump is capable of developing a pressure of 39 lb. per sq.in., and is equipped with a ½-hp. motor running at 1,725 r.p.m. It has no packing, and thereby eliminates unnecessary friction. This permits full benefit of the ball bearing construction.



A vertical coolant pump that will develop a pressure of 39 lb. per sq. inch

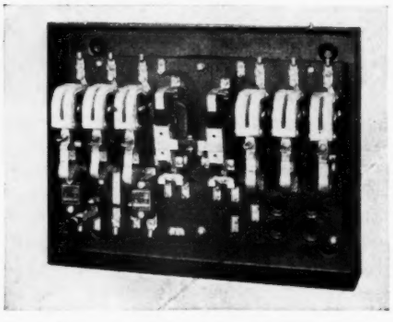
The intake is constructed with a stationary device of three curved blades to prevent the water from whirling. This feature prevents the entrance of air, making the flow uniform and free from air bubbles.

■

General Electric Magnetic Reversing Switch

This magnetic reversing switch of improved design, announced by the General Electric Company, Schenectady, N. Y., is designated as CR-7009-B-18, and supersedes the model B-5 switch of the same type. It has sufficient capacity to control motors of greater horsepower than the former model.

This improved switch is designed to throw small a.c. motors directly across the line. It consists of two triple-pole, mechanically interlocked, magnetically operated contactors with restricted-type blowouts, and with a normally-open interlock on each contactor. It also has two hand-reset temperature over-load relays. The contactors are mounted side by side on a molded base, instead of back to back.



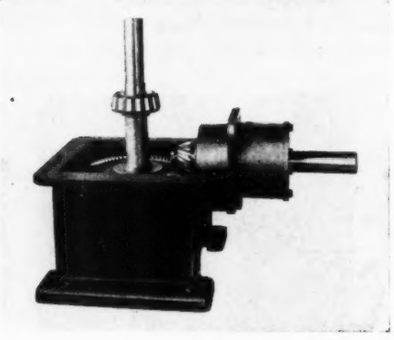
Reversing switch designed for throwing small a.c. motors across the line

The device is contained in a drawn-shell steel inclosing case. It is available for voltages from 110 to 600, to give from 7½ to 15 hp. on 3- or 2-phase, 3- or 4-wire systems, and from 3 to 10 hp. on single-phase circuits.

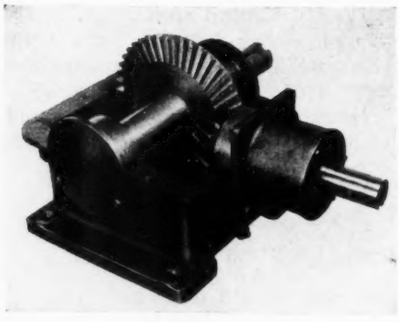
■

James Right-Angle Speed Reducers

TWO spiral-bevel-gear, right-angle speed reducers have been placed on the market by the D. O. James Manufacturing Co., 1114 W. Monroe St., Chicago, Ill. The first of these has a vertical driven shaft, whereas the second has a horizontal driven shaft. The spiral bevel gears are mounted on Timken roller bearings, and the output speeds may range as high as 2,400 r.p.m., but ordinarily do not go beyond 1,800 r.p.m., the motor speed. Ratings range from ¼ to 100 hp., and ratios from 1 to 1 and 6 to 1. Larger reductions are obtained by the combination of the spiral bevel gear and planetary spur gears with ratios of 8 to 1 to 1,500 to 1.



Right-angle speed reducer of the vertical type

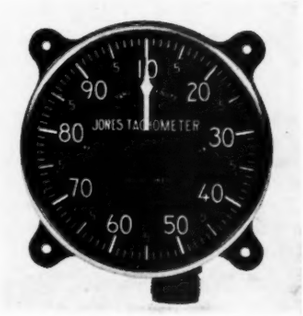


Right-angle speed reducer of the horizontal type

NEW MATERIALS AND PARTS

Jones Industrial Tachometer

CENTRIFUGAL operation is a feature of the industrial tachometer placed on the market by the Jones-Motrola Sales Company, 370 Gerard Ave., New York City. A small governor within the instrument is driven by means of a flexible shaft. The rise and fall of the governor controls



Various scales can be obtained for this centrifugal - type tachometer

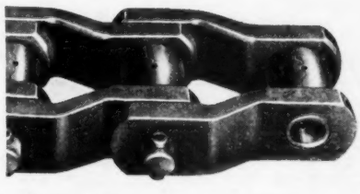
the operation of the pointer, which may be arranged for different types of scales. For example, the scale may read in yards per minute for textile machines, revolutions per minute, feet per minute, and revolutions per hour.

■

"Hyper" Heavy-Duty Chain

SPECIAL pins and cotters are used in the heavy-duty chain, announced under the trade name of "Hyper" by the Link-Belt Company, Indianapolis, Ind. The pins, the bushings, and the holes in the side bars are ground accurately, and the cotters are of a special type designed not to work loose. They are expanded into the holes provided in the pins.

It is claimed that the chain combines great strength and durability. The "Hyper" SS-40 chain has an ultimate strength of 75,000 lb. and the SS-124, an ultimate strength of 150,000 lb. Because the tolerances are held to 0.001 in. during manufacture, it is said that the chain has unusual durability.



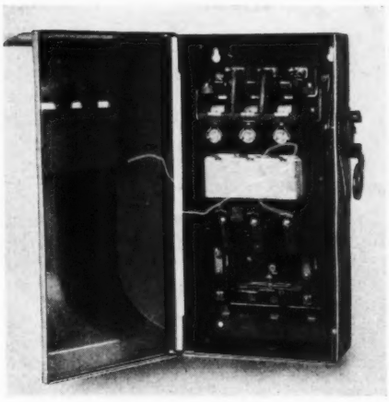
The special cotters are designed not to work loose

■

Westinghouse Linestarter and Switch

A COMBINATION linestarter and safety switch designated as Class 11-200-HD, has been developed and placed on the market by the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. This apparatus occupies a minimum amount of space, being much more compact than a linestarter and safety switch mounted in separate cabinets.

A feature is the provision for inserting a plug-type meter test jack



Linestarter combined with a safety switch

to determine the load on the machine while the motor is in operation, and while the door of the cabinet is closed. The equipment can be used with or without fuses, jumpers being supplied for use when fuses are not employed. The safety switch has quick-break contacts, and the handle is interlocked with the cover, thus preventing opening of the door when the contacts are closed.

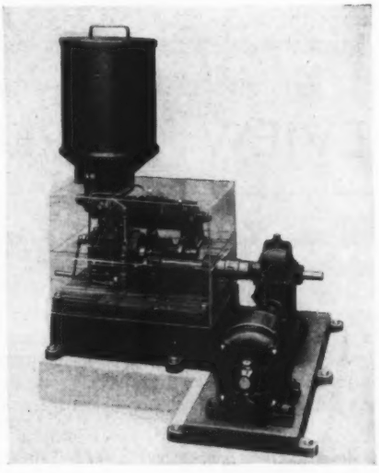
■

"Anderson" Grease Pump

MEASURED quantities of grease are delivered to from four to twelve bearings by each "Anderson" grease pumping unit. This device, shown in the accompanying illustration, has been placed on the market by the Hill - McCanna Company, Chicago, Ill. It is positive in operation, and will maintain a pressure up to 5,000 lb. per sq. inch.

Grease is introduced into the feeding system of the Anderson mill-type grease pump by means of a displacement pump. A distributor head with the requisite number of leads is directly connected to the discharge side of the pump. Indexing of the head from feed to feed, is secured by means of a ratchet attachment, which permits indexing on the suction stroke, and remains fixed during the discharge stroke.

Delivery lines are attached to the



From 4 to 12 feeds per unit may be obtained on this grease pump

distributor head and lead to the connections of the bearings. Present models consist of 4, 6, 8, 10 and 12 feeds per unit. Special sizes up to 24 feeds per unit may be obtained. Where more than this number are necessary, two or more units may be connected with a common driving mechanism. A steam heating element is installed in the bottom of the grease hopper directly above the intake valve to facilitate handling of heavy greases during cold weather. The grease hopper has a capacity of 60 lb. A screen is installed beneath the steam heating element to remove any foreign matter before the grease enters the pump.

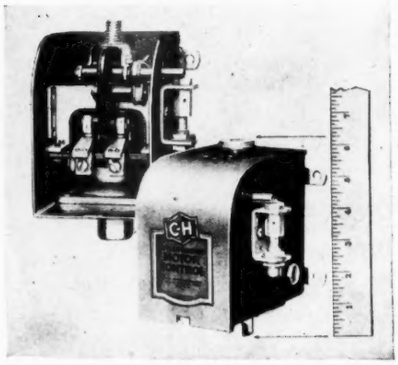
■

Cutler-Hammer Small Pressure Regulator

SYSTEMS containing water, air, gas, and other fluids at from 30 to 200 lb. per sq.in. can be controlled by means of the single-pole pressure

NEW MATERIALS AND PARTS

Pressures from 30 to 200 lb. per sq.in. can be controlled by means of this single-pole regulator



regulator put on the market by Cutler-Hammer, Inc., 80 12th St., Milwaukee, Wis. This device is small in size, and is designated as Bulletin 10,006. It can be used as a starting switch for motors up to one horsepower, 230 volts, a.c. or d.c., or as a pilot switch in the control circuit of automatic starters for larger motors. The regulator closes the circuit at low pressure and opens the circuit at high pressure. For air compressor service, a small unloader device relieves the back pressure.

To withstand moist atmospheres, the inclosing case is black japanned and the bright parts are cadmium plated. Double-break silver contacts prevent pitting.

REVIEW OF RECENT PATENTS

Parts and Mechanisms

Henry Humphreys, of Oldham, England, has been granted patent 1,730,730 on a magnetic chuck, with a one-piece faceplate, having apertures, pole pieces in close contact with the faceplate, and means for rendering magnetic certain areas inclosed by groups of apertures.

To the Edwin B. Stimpson Company, has been assigned patent 1,730,750, on a rivet-feeding mechanism combining a movable pocket, a gravity feed guideway adapted to align with the pocket, a plunger adapted to engage the rivet head, and other co-operating parts.

The Metallgesellschaft Aktiengesellschaft, Frankfort-on-the-Main, Germany, has been assigned patent 1,730,937, on a centrifugal friction clutch, having means carried by the driving member to release centrifugally operated elements when the driving member reaches a predetermined speed.

The Brown-Lipe Gear Co., is assignee of patent 1,731,064 on a multiple-disk industrial clutch having, among other parts, a brake member and a shifting fork interposed between the end of a hub of the outer drum and the brake member.

Patent 1,731,482, assigned to Cincinnati Grinders, Incorporated, covers an oscillating mechanism for spindles, including a reciprocable piston, a pump within the piston, means for actuating the pump, and operating other co-operative parts.

The Barnes Drill Co. has been assigned patent 1,727,984 on a spindle supporting structure for drilling machines, comprising a sleeve mounted for longitudinal movement, a rack mounted on the outer periphery of the sleeve, and other co-operating parts.

Patent 1,727,567 granted to Joseph L. Schmidling of Milwaukee, Wis., relates to a stock-feeding mechanism for automatic screw machines, combining a reciprocable sleeve, a tubular work-receiving member, and other parts combined in novel relation.

To the Reeves Pulley Co. has been assigned patent 1,731,827 on a driving belt formed from a plurality of links having inclined friction end faces, rocker pin connections, and other parts.

A simplified mounting for concentrically-suspended sleeves, involving the use of a special form of ball bearing, is covered by patent 1,731,670, assigned to The Cincinnati Bickford Tool Company.

Materials

Patent 1,722,358, assigned to the Western Electric Co., Inc., covers a ternary alloy comprising not more than 4 per cent antimony, not more than 1 per cent arsenic and the remainder lead.

The patent also covers a method of making the alloy.

PUBLICATIONS

BEARING METAL, WHITE BRASS. The Cramp Brass & Iron Foundries Co., Philadelphia, Pa., has issued Bulletin No. 10 entitled "Parsons' White Brass S.A.," a bearing material for marine engines, Diesel motors and turbines.

BEARINGS, ROLLER. The Roller Bearing Co. of America, Trenton, N. J., announces catalog No. 40, "Heleflex Bearings," which describes its helically wound, straight radial type roller bearings, and takes up the shock absorbing characteristics, the roller assembly, and bearing mountings and housings.

BEARINGS, ROLLER. The Hyatt Roller Bearing Co., Motor Bearings Division, Detroit, Mich., has published a general engineering bulletin on the application of Hyatt roller bearings to motor cars, trucks and buses. It gives the characteristics, load capacities, limits, mounting suggestions, computations, and a diagram of installations.

CHAIN. The American Chain Co., Inc., Bridgeport, Conn., has published booklet No. 404, giving tables of sizes, weights, loads, and how to take measurements. The data apply to welded chain.

CONTROLLERS. The Square D Co., Detroit, Mich., has published catalog No. 35-1-C on the products of its Industrial Controller Division, Milwaukee, Wis. The catalog contains descriptions and specifications of a.c. and d.c. motor controllers.

COUPLINGS. The Smith Power Transmission Co., 1213 West Third St., Cleveland, Ohio, has published a booklet entitled "Flexoid Industrial Couplings," showing their applications to various machines.

MOTORS. The Master Electric Co., 100 Davis Ave., Dayton, Ohio, through its booklet "Settings of the Power Diamond," presents representative applications of "Master" motors.

MOTORS, INDUCTION. The Reliance Electric & Engineering Co., Ivanhoe Road, Cleveland, Ohio, has published a bulletin No. 106, entitled "Type AA Reliance Induction Motors." These machines are provided with ball bearings and are intended for two- or three-phase, a.c. circuits.

PUMPS, COOLANT. The Ruthman Machinery Co., Cincinnati, Ohio, has issued Catalog 1930, "Gusher Coolant Pump," describing the various models manufactured and showing the types of machine tools to which they may be applied.

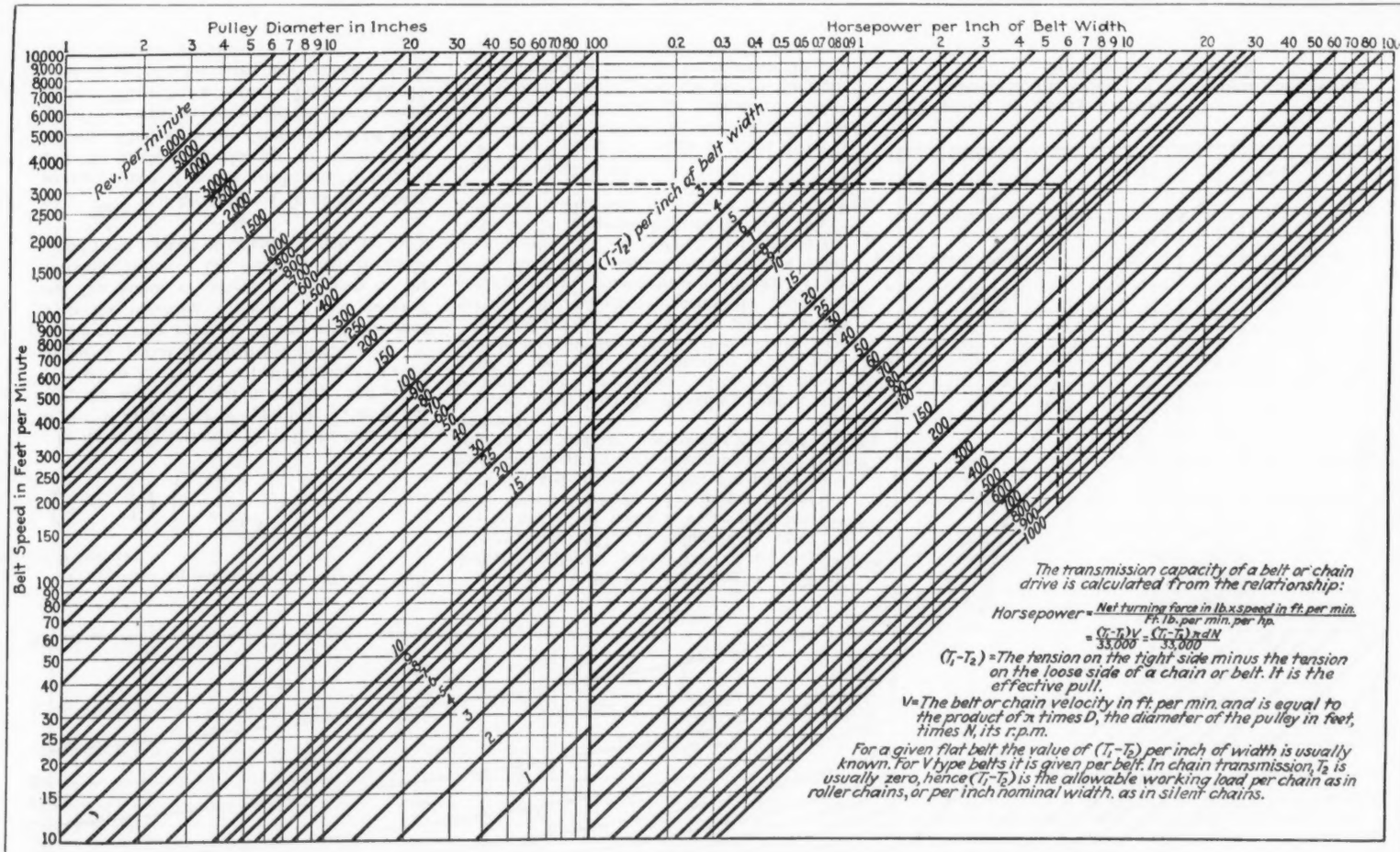
SPROCKETS FOR ROLLER CHAIN. The Diamond Chain & Manufacturing Co., Indianapolis, Ind., has published a booklet giving the list prices of its sprockets for roller chain.

SWITCH, PRESSURE. The Allen-Bradley Co., Milwaukee, Wis., has published Bulletin 830 on its automatic pressure switch and accessories to be used in connection with automatic motor control for compressors, pumps, and other equipment.

SWITCHES. The Square D Co., Detroit, Mich., has published catalog No. 35-S on safety switches of various types, plugs and sockets, end plates, meter service switches, and fittings.

TUBING, FLEXIBLE. The Seamlex Corporation, 30 Church St., New York. N. Y., has published Bulletin No. 302, covering its "Seamlex" flexible, seamless all-metal hose in various styles and sizes.

Belt Horsepower Charts


Pulley Diameter in Inches
Horsepower per Inch of Belt Width
Belt Speed in Feet per Minute
Rev. per minute
(T_1-T_2) per inch of belt width
The transmission capacity of a belt or chain drive is calculated from the relationship:
Horsepower = Net turning force in lb. x speed in ft. per min. / Ft. lb. per min. per hp.
$= \frac{(T_1-T_2)V}{33{,}000} = \frac{(T_1-T_2)\pi DN}{33{,}000}$
(T_1-T_2) = The tension on the tight side minus the tension on the loose side of a chain or belt. It is the effective pull.
V = The belt or chain velocity in ft. per min. and is equal to the product of π times D, the diameter of the pulley in feet, times N, its r.p.m.
For a given flat belt the value of (T_1-T_2) per inch of width is usually known. For V type belts it is given per belt. In chain transmission, T_2 is usually zero, hence (T_1-T_2) is the allowable working load per chain as in roller chains, or per inch nominal width, as in silent chains.

THIS CHART shows graphically the various quantities in a belt or chain transmission. For example, a certain belt is capable of operating with an effective pull, $(T_1 - T_2)$ of 60 lb. per in. of width. It is to transmit 30 hp., running on a pulley 20 in. in diameter, making 600 r.p.m. It is required to find the necessary belt width.

Entering the chart at the top on the scale "Pulley Diameter in Inches," trace down on the line representing 20 in. diameter, to the diagonal line reading 600 r.p.m., as shown by the dashed line. To find the belt speed, trace to the left; the "Belt Speed in Feet per Minute" scale shows 3,160 ft. per min. Trace to the right along the dashed line to the diagonal representing $(T_1 - T_2)$, equal to 60. Then tracing upward vertically, the horsepower scale shows that 5.7 hp. can be transmitted per inch of width of belt. Transmission of 30 hp. will require a belt 30 ÷ 5.7, or 5.26 in. wide.

The chart can also be used to find the effective pull necessary to transmit a certain horsepower with a given pitch diameter and r.p.m., as illustrated in the following example. It is desired to find the effective pull necessary to transmit 4 hp. from a shaft operating at 600 r.p.m. and using a 6-in. pitch diameter sheave. Find the pitch speed as before and trace to right, also find the required horsepower and trace down. At the intersection of these lines read 140 lb. as the effective pull required.

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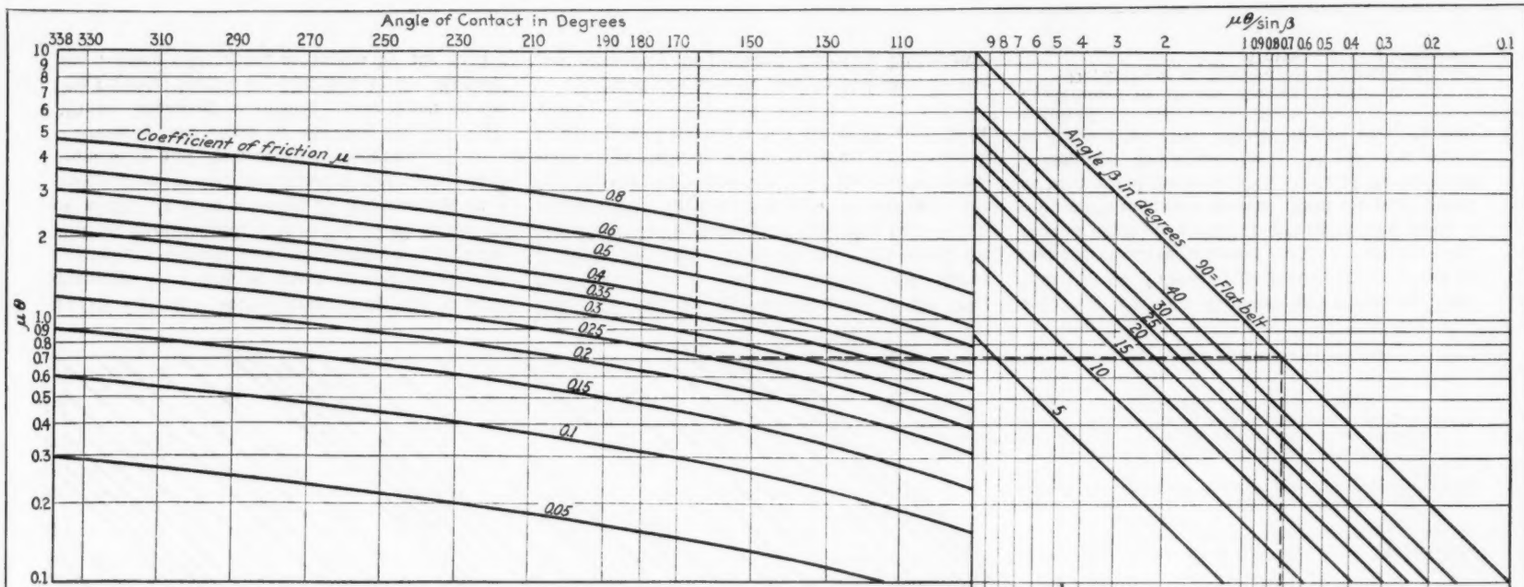
Belt Horsepower Charts



The general equation for the effective pull of a belt is:

$$\left(T_1 - \frac{wv^2}{g}\right)\left(\frac{e^{\frac{\mu\theta}{\sin\beta}}}{e^{\frac{\mu\theta}{\sin\beta}} - 1}\right) = T_1 - T_2$$

In the above formula, sin β is the half angle of the V-groove for V-type belt. For a flat belt, the angle is equal to 90 deg. and sin β is equal to 1. Hence, a flat belt may be considered a special case of the V-belt.

The working value of T_1 can be determined from the breaking strength of the material and the factor of safety to be used in the particular design. The value of wv^2/g can be found from a chart or calculated, and the value of $e^{\frac{\mu\theta}{\sin\beta}}$ can be obtained from the accompanying chart if ν, the coefficient of friction and the angle θ of the arc of contacts are known. Charts for the determination of these quantities will be presented in forthcoming issues. The relation between T_1, the tight side tension, and T_2, the slack side tension, can be found from the accompanying chart.

Example—A flat belt operating on a 20-in. diameter pulley is making 600 r.p.m., the arc of contact is 165°. A value of T_1 equal to 120 lb. per in. of width is to be used for the belt. The belt weighs 0.150 lb. per ft. per in. of width and in contact with the pulley face has a coefficient of friction equal to 0.25. It is required to find the horsepower the belt can transmit.

From Chart 1 on the preceding page it will be found that v, the velocity of the belt, equals 3,160 ft. per min. The quantity wv^2/g may be calculated or determined from a chart.

To find $e^{\mu\theta}$ enter this chart at the top, at the vertical line which represents the value of angle of arc of contact equal to 165 deg. Trace down until the diagonal representing a value of ν equal to 0.25 is reached, and then to the right to the diagonal labelled 90 deg., which represents a flat belt, then down to the curve and then horizontally to the left, where we read $e^{\mu\theta}$ equal to 2.1.

By substituting this value of e sin β or, as in this example, $e^{\mu\theta}$ in the above equation, the value of $T_1 - T_2$ may be calculated. With this quantity known, and the use of the chart on the preceding page, the horsepower per inch of width of belt may readily be obtained.

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